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TITLE : Sustainaility of Coffee Agroforestry Systems in Central America; coffee quality and environmental impacts

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SUMMARY
Dr. Philippe Vaast (CIRAD), Coordinator

The objective ofthis **summary report** is to give an overview of the main technical activities undertaken by all the partners of the CASCA project during the first year (November 2001 - October 2002) and the difficulties encountered.

Two consortium meetings were held during this first year, one at the beginning of the project (November 26-30 of2001) in the headquarters of CATIE in Turrialba, Costa Rica and a second one (October 23-30 of2002) in the headquarters ofUNA in Managua, Nicaragua.

General progress

As exposed in details in the WP reports and activity reports of CASCA partners, a large amount of fieldwork has been implemented during this first year. Experimental sites have been selected late 2001 and data gathering is well underway in Costa Rica since March 2002 for all four biophysical Work Packages (WP's 2, 3, 4 & 5). Fieldwork in Nicaragua has started in May 2002 with the onset of the rainy season.

For the socio-economic Work Packages (WP's **1,7** & 8), activities are also on the right track. The methodology for the characterization of farms and agroforestry (AF) systems was discussed during the initiation meeting and refined during a week of field visits and discussions in early April 2002. The socio-economic questionnaires have been developed and surveys have been undertaken from May to October 2002 in four coffee producing regions of Costa Rica and Nicaragua.

Overall, **the project has got off to a good start and very significant progress** has been performed to meet project schedule in terms of deliverables.

- The database on farmers AF knowledge and main AF characteristics in four regions of three Central American coffee producing countries has been updated (see activity report ofWP1).
- The model of light partitioning between coffee and associated trees is well underway (see activity report ofWP2).
- Important data have been gathered on water consumption of coffee and associated trees (see activity report ofWP2).
- The first draft of a model simulating carbon allocation within the coffee plant has been developed and published (see activity report ofWP3).
- Significant progress has been made in the understanding of processes regulating coffee quality (see activity report ofWP3).

- Important data have been gathered on nitrogen cycling in target coffee AF systems (see activity report of WP4).
- A database on carbon accumulation has been developed and put on the Web and many data have been collected in the field (see activity report of WP5).
- The leader of WP6 has developed the backbone of an integrated plot model (see activity report of WP6).
- The development of an economical model is under way with data collected from surveys in Nicaragua and Costa Rica (see activity reports of WP1 & WP7).
- A general framework has been developed by WP leader regarding regional up-scaling and policies (see activity report of WP8).

The only weak point concerned activities in Guatemala. At the end of this first year, no activity in the field has been initiated in this country. Due to the coffee crisis (very low prices for the last 2 years), the majority of the research and extension personnel of ANACAFE (one of the two national coffee institutions in the nCA-PROMECAFE Network) have lost their jobs in January 2002. As a consequence, site selection in Guatemala has not been completed during the first year as planned. However, research activities on beneficial effects of coffee AF systems on water quality and socio-economic surveys will be starting in early 2003 with the benefit of methodological fine tuning during the first year of CASCA activities in Nicaragua and Costa Rica.

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Scieotific anoual report
Dr. Phili e Vaast (CIRAD), Coordinator

The objective ofthis **scientific annual report** is to give an overview of the main technical activities undertaken by aU the partners of the CASCA project during the first year (November 2001 - October 2002) and the difficulties encountered.

Months of activities

With the exception ofresearchers from IICA-Promecafé (ANACAFE in Guatemala), aIl project partners have had an important input in terms oftime spent on the activities dedicated to the project. Out of the **177.9 months initially planned** for the first year, **147.9 months have been dedicated** to CASCA activities (see details ofmonths of activities per partner at the end ofthis document). The deficit is mainly due a low hiring oftemporary workers on the part ofIICA-Promecafé in the absence of field activities in Guatemala and the difficulties encountered by UNA in Nicaragua to hire outside personnel due to internaI administrative procedures.

This report of scientific activities is presented by Work-packages. Details of the major results are presented in the forms of WP reports with graphs and tables in the ANNEXES.

Work-Package 1: (Central American coffee agroforestry knowledge)

The main objective of this WPl is coUecting and analyzing data on farmers' agroforestry knowledge, over the first 24 months of the project, in major coffee-growing ecological zones of the 3 countries (Costa Rica, Nicaragua & Guatemala) considered in the project.

One technical meeting, with participation of representatives of the 5 partners, was in April 2002 in Nicaragua and in Costa Rica in order to to select the regions to be surveyed and to design field questionnaires for socioeconomic surveys.
As a leader ofthis WPl, CATIE (Dr. Eduardo Somarriba) has coordinated with partners the field surveys undertaken in Costa Rica and Nicaragua (see WPl report).
Students conducted surveys of farmers about their strategies in terms of coffee cultivation and agroforestry practices. Four students ofUNA undertook surveys in one region of Nicaragua and 2 Students from CNEARC, France, in one region of Costa Rica. More than 60 farms in Costa Rica and 50 in Nicaragua have been surveyed and the data registered in excel format.

Dr. Somarriba also updated the database on CUITent coffee Agroforestry (AF) practices with the help ofa CATIE technician (Mario Cervantes). The Database comprised more than 5 case studies done over the last 10 years in 3 countries of Central America (see WP1 report).

Deliverables and Planned activities in 2003

No deliverables were due in 2002. Neverthe1ess, the De1iverable *D101D1.1* "Database of CUITent coffee AF practices" is completed and will be actualized with studies performed during this first year in Costa Rica and in Nicaragua as weIl as the one to be undertaken in 2003 in Guatemala.

Work-Package 2: (light and water partitioning at plot scale)

The main objective ofthis WP2 is assessing **light and water partitioning** between coffee and associate tree in a few target coffee AF systems of regions with distinct agro-ecological conditions.

CIRAD (Dr. Jean Dauzat) and **CATIE** (Dr. Gustavo Anzola) have been involved in designing field methodology to **quantify shade provided by five timber trees in 4 coffee AF systems, collecting data on light interception** by the trees using a photo fish-eye apparatus and in the **development of a model simulating light partitioning** between the associate tree and the coffee stratum (see WP2 report for more details).

A Masters student of CATIE has worked for several months registering at 3 periods of the year (final of the dry season, transitional period to the rainy season and during the rainy season) the Photosynthetically Active Radiation (PAR) in 3 AF systems (Coffee associated with either *Terminalia ivorensis*, or *Eucalyptus deglupta*, or *Erythrina poeppigiana)* in comparison to coffee in full sun. The Masters student will be defending his thesis in early December 02 (see abstract in the annexes of report of CATIE). One article is in preparation for publication in 2003 in the Agroforesteria en las Americas. The results of these investigations show that coffee receives about 55 to 70 % of full sun under shade of *Terminalia ivorensis* and *Eucalyptus deglupta*, respectively (see annex Report of WP2 fig.1). They demonstrate that coffee grows better under shade trees in the sub-optimal conditions of the study. Coffee produces more in these AF systems than in full sun due to a lower fruit drop over the production cycle (see report of CATIE, Table 1).

CIRAD (Dr. Philippe Vaast) and **CATIE** (Rudi van Kanten and Pablo Siles) have been strongly involved in designing field methodology to **collect data on transpiration of both coffee and tree strata using sap f10w measurements.** Dr. Régis Tournebize of **INRA,** the subcontractor of CIRAD, was also involved in designing field methodology and came for a week of mission in March 2002 (see mission report in annexes of CIRAD Report).

A Ph.D student of CATIE has been collected data from December 01 to June 02 as part of his doctoral work; one technician of CATIE has followed up the collection of these data during the rest of the year 2002. A methodological article on how to perform sap flow measurements in AF systems will be published late 2002 in Agroforesteria en Las Americas. These results show that coffee transpiration rate increased rapidly after sunset and decreased sharply in the afternoon after 2:00 PM. Especially during the rainy season, they also show that water consumption of coffee was significantly lower under shade of timber-trees. This is an indication of lower heat stress of the coffee under shade. Water consumption of coffee was lower during the dry season that in the wet season pointing out to water limiting conditions during that period. Shade trees had a lower but more regular transpiration rate in the dry season than in the rainy season. These results demonstrated that daily tree transpiration followed weIl the calculated Eto (see Annexes ofWP2 report and CIRAD and CATIE reports for figures and tables).

Deliverables

No deliverables were due in 2002.

Nevertheless, the Deliverable D11/D2.1 "Comprehensive model of light partitioning in coffee AF systems" due at the end ofyear 2 (24 Months) is weIl advanced (see Report of WP2).

Furthermore, significant progress has been made to start, during year 2, the first draft of the Deliverable D15/D2.2 "Water balance model at plot scale" due at the end ofyear 3 (36 Months).

Planned activities in 2003

In 2003, intensive field measurements on light partitioning and on soil water content and water consumption of coffee and trees will be pursued in coffee AF systems currently under investigation and new ones to parameterize the models.

Work-Package 3: (coffee ecophysiology and quality)

The main objectives ofthis WP3 are studying physiological responses of coffee leaves to micro-environmental field conditions, developing a model of carbon production and allocation in coffee plants as weIl as investigating the mechanisms responsible for coffee quality.

CIRAD (Dr. Philippe Vaast), UNA (Dr. Victor Aguilar) and CATIE (Jobert Angrand and Pablo Siles) have been involved in quantifying carbon allocation between fruit and shoot. With a CO_2 analyzer bought with CASCA equipment funds, CIRAD and CATIE have performed measurements of leaf and fruit photosynthesis, stomatal conductance and photo-inhibition due to high solar radiation in optimal ecological conditions for coffee growth and production on the experimental station of CICAFE, Central valley, Costa Rica. AlI these measurements have been used to parameterize a carbon model at the branch level (see Annexes of WP3 report and reports of CIRAD and CATIE for figures and tables). One article has been published in 2002 in Acta Horticultura (see annex of CIRAD report). Two articles for international journals are in preparation.

CIRAD and nCA-PROMECAFE (CICAFE of Costa Rica) have been involved in quantifying the effects of shade and fruit load on the quality of coffee in terms of physical (bean size) biochemical (saccharose, fat content,.. etc) and organoleptic (acidity, bitterness, preference) properties. More than 200 analyses (biochemical and tasting) have been performed by CIRAD (B. Guyot and 1.J. Perriot) in its laboratory in Montpellier.

One article has been accepted for publication in 2002. Another one has been submitted in October 2002. Most relevant results are exposed in WP3 report.

Deliverables

No deliverables were due in 2002.

Nevertheless, the Deliverable *D81D3.1* "Scientific report on physiological responses of coffee to microclimatic conditions" due in year 2 (20 Months) and the Deliverable *D91D3.2* "Report ofrules of carbon allocation" due in year 2 (20 Months) are weIl advanced. One article has been published in 2002 in the proceedings of the Sixth International Symposium in Fruit Research and Orchard Management (Acta Horticulturae 584:57-62) and several articles for international journals are in preparation (see Report of WP2).

Planned activities in 2003

A new trial, in a commercial coffee field, Orosi, Costa Rica, has been installed in October 2002 to test different levels of shade on coffee physiology and coffee quality. Intensive measurements will be undertaken in 2003 to parameterize the model of carbon allocation and increase our understanding on processes responsible for coffee quality.

Work-Package 4: (Nitrogen cycling, leaching, uptake and emissions)

The main objectives ofthis WP4 are to **measure nitrogen** (N) **fluxes** in a few target coffee management systems, **to model N cycling** in order to **predict the N losses and accumulation**, and to carry out environmental evaluation at catchment's scale.

CIRAD (Dr. Jean-Michel Harrnand), **UNA** (Dr. Victor Aguilar) **nCA-Promecafe** (Victor Chavez ofCICAFE), **CATIE** (Pablo Siles, Hector Avila and Vanessa Reina Renderos) and CEH (Dr. Dte Skiba) have been strongly involved in **designing field methodology and quantifying N fluxes** in 4 agroforestry systems in Costa Rica and Nicaragua.

Data have been collected on N mineralization, N accumulation in coffee plants and soil profile depending on intensities of N fertilization and management, **losses via leaching and nitrous oxide emissions** in 4 coffee AF (see WP4 report for more details). These studies will also provide results for WP2 (water cycling) and WP5 (C sequestration).

Robert Oliver took in charge a lot of N analyses in his laboratory in CIRAD in Montpellier. He visited CATIE in May 2002 in order to install the Nitrogen analyzer bought by CATIE with CASCA funds and to teach the person in charge of the equipment about its functioning. Dr. Etienne Dambrine from INRA (subcontractor of CIRAD), Nancy, was also strongly involved in designing methodology for nitrogen and carbon studies during the first year of the project. Purchase, field application and analyses of N_{15} have been rescheduled for 2003.

Deliverables

One deliverable was due in 2002, the Deliverable D41D4.1 "Literature review on N measurements in coffee AF systems" due in year 1 (12 Months). This task has been achieved by Dr. Harmand and 2 graduate students of CATIE as part of their literature review oftheir Masters thesis to be defended in late November 2002. The document is in Spanish and should be translated into English in early 2003.

Planned activities in 2003

More measurements, involving two new graduate students (one in Costa Rica and one in Guatemala), will be undertaken in 2003 to improve our understanding ofN cycling and parameterize the model ofN flux at plot scale due at the beginning ofyear 4.

Work-Package 5: (carbon sequestration)

The main objectives of this WP5 are to **measure carbon sequestration** in biomass and soil of a a few target coffee AF systems, to **create a database** of C sequestration in coffee AF systems in Central America, and to **develop a model** predicting C sequestration at the site scale and regional scale.

CIRAD (Dr. Jean-Michel Harmand and Sergio de Miguel), **UNA** (Dr. Victor Aguilar) **nCA-Promecafe** (Victor Chavez ofCrCAFE), **CATIE** (Pablo Siles, Dr. Markku Kanninen) have been undertaking measurements ofbiomass of coffee and *Eucalyptus deglupta* in two plantations in the southern lowland part of Costa Rica. Characteristics (height, crown projection, diameter at breath high) and biomass of *Eucalyptus deglupta* in coffee plantations of 2, 4, 6 and 7 years were performed to obtain allometric relationships. Biomass of coffee trees was also quantified as well as that of leaf fall and soillitter (see WP5 report for more details). One graduate student in forestry from ENGREF, France, undertook his research works in the experiments. He will be defending his thesis in December 2002.

CATIE (Krystell Hergoualc'h) has contributed to this WP through the elaboration of a database in Access recapitulating all (around Il) studies undertaken over the last 25 years on C flux and accumulation in coffee AF systems in Central America and other coffee-producing countries. This database is accessible via the website of CATIE (see report of WP5 for details).

Deliverables

One deliverables was due in 2002, the Deliverable *D51D5.1* "Database on C sequestration in coffee systems" due in year 1 (12 Months). This task has been achieved by Krystell Hergoualc'h (CATIE) as exposed earlier. This database a1so comprised the deliverable D6/D1.2 "Database on coffee agroforestry studies" only due in year 2 (18 Months).

Planned activities in 2003

More field measurements will be undertaken in 2003 to improve our understanding of C accumulation and cycling in coffee AF systems and to parameterize the model of C sequestration at plot scale due at the beginning ofyear 4. In 2003, a student of CATIE will survey farmers in 4 regions of Costa Rica and measure in the field the accumulated biomass of 4 timber-tree species in coffee AF systems to look at the effect of farm management and local ecological conditions on tree growth.

Work-Package 6: (integrated plot modeling)

Dr. Marcel van Oijen **(CEH)** has **developed an initial version of an integrated plot model** for coffee growth with and without accompanying trees (see report ofWP6). The model has been implemented in the modelling software Matlab/Simulink. Its allows both graphicaI representation of the model and efficient analysis. The model is already operationaI but its structure is intended following discussions with partners.

Other partners have contributed indirectly to this WP during workshops discussions on its format and by collecting meteorological and field data on coffee and tree biomasses that will be used as parameters for the mode!.

Deliverables

One deliverable was due in 2002, the Deliverable *D3/D6.1* "Review of carbon allocation modeling approaches in fruit trees" due in year 1 (6 Months). A first draft ofthat review has been written by Dr. M. van Oijen and is under revision by the two co-authors (Dr. J. Dauzat and Dr. Ph. Vaast).

Planned activities in 2003

To perform runs of the integrated plot model and to refine its parameterization with meteorological and field data provided by leaders ofbiophysical workpackages (WP2, 3, 4 &5).

Work-Package 7: (economic modeling at farm scale)

CIRAD (Dr. Philippe Bonnal as leader ofthis WP, Sten Guezennec, Alexandre Nougadère, graduate students from CNEARC), **UNA** (Prof. Glenda Bonilla and 4 graduate students) **nCA-Promecafe** (Orlando Moya and Carlos Fonseca ofCICAFE), **CATIE** (Dr. Eduardo Somarriba) and CEH (Dr. Gerry Lawson) have been involved in the elaboration of questionnaires and the supervision of 6 students in the field in Costa Rica and Nicaragua. Valuable information on the diversity of production systems, farm incomes, costs of inputs and labor has been collected. The framework of an economic model has been developed to allow estimation of farmers' revenues according to farm size and management (see report ofWP7).

Deliverables

No deliverables were due in 2002.

Planned activities in 2003

Socioeconomic farm surveys will be undertaken in Guatemala in 2003. A synthesis of household surveys will be performed as a due deliverable at the end of 2003. A first draft of an economic model will be parameterized with data collected in 2002 in Costa Rica.

The framework of a more complex economic model to evaluate management scenarios will be undertaken with the goals oftaking into account economical risks (price of coffee) and climatic factors (good to bad climatic conditions affecting coffee and other agricultural revenues of farms).

Work-Package 8: (regional up scaling and policies)

Objectives ofthis Workpackage deal with upscaling results from the Biophysical plot model and from the socioeconomic model to gain an understanding of the validity of conclusions in a wider geographical area, and assessing the market opportunities for coffee-agroforestry systems in world and European markets: Specifically:

1. To determine the requirements to achieve 'sustainable'; 'fair-trade' or 'eco-friendly' labels on the European markets as well as the long-term potential of marketing this coffee in European countries
2. To extrapolate farm-scale socio-economic survey data and model predictions from WP7 to a regional scale using population and agricultural census information
3. To extrapolate biophysical predictions ofyields and environmental impact from the plot scale biophysical model (WP6) to larger areas and regions using databases of soil and climate information.
4. To examine the regional implications for coffee production and farm livelihoods of changing climate, economic incentives and widespread uptake of 'eco-friendly' cultivation systems.

Dr. Gerry Lawson, as WP leader **(CEH)** has exposed rus methodology and during the two meetings held during the first year of CASCA. An initial survey of the market for different coffee labels was conducted with identification of five categories of labelling schemes (see report ofWP8). For regional economic upscaling, the availability of information has been checked with Coffee Growers Organisations (ICAFE and PROMECAFE). A literature review has been undertaken on the environmental impacts of coffee plantations.

<u>Deliverables</u>
No deliverables were due in 2002.

<u>Planned</u> <u>activities</u> <u>in</u> <u>2003</u>
There were no milestones planned in the first year, but substantial progress is expected towards the following milestones in the next 12 months:

1. Completion of interviews with European traders and estimates of premium prices that European consumers are willing to pay for eco-friendly produced coffee (Month 42)
2. Extrapolation of outputs from the socio-economic farm model (WP7) to predict impacts of different management scenarios *on farmers* at the level of administrative region (Month 36)
3. Extrapolation ofplot-scale biophysical model results to predict regional yield and environmental impact on a GIS grid, for at least one country (Month 36)

4. Integration of socio-economic-ecological impacts of coffee management systems in the context of broader environmental impacts on stakeholders (Month 40)

Work-Package 9: (project management, dissemination, and exploitation)

As leader ofthis WP9, **CIRAD** (Dr. Philippe Vaast) has been co-organized with **CATIE** the **initial meeting** of CASCA in late November 2001 at CATIE headquarters in Costa Rica and the **second meeting** with **UNA** in late October 2002 at UNA headquarters in Nicaragua.

As coordinator, CIRAD (Dr. Philippe Vaast) has produced the **6-month report** of activities as weIl as this **present technical report and the annual financial report (Dr.** Philippe Vaast and Ms Catherine Potvin) with the collaboration of aIl partners (Partner reports and WP reports in annexes).

Through **scientific publications** (see annexes), partners of CASCA have contributed to the exploitation and dissemination of results.
Three **oral presentations** on the objectives of the project have been performed by CIRAD members during **coffee congresses** and workshops **in Costa Rica, Guatemala and Nicaragua.**
An **article** has been published in Plantation, Recherches et Development to present the project to a large audience in French and English (with a summary in Spanish).
A **brochure** is in preparation for the **Salon International d'Agriculture** to be held in Paris, France, from February 22nd to March 3rd 2003 with the objective to present the CASCA project to the general public and the European coffee sector.

The elaboration of a **on-lîne database** on coffee AF studies and C sequestration has been achieved by CATIE.

A Cdrom is in preparation, recollecting aIl the presentations done by partners and WP leaders during the two CASCA meetings; this CDrom will be distributed to aIl partners and representations of E.U in countries.

A **website in spanish,** to be hosted by CAIlE, is also in development and should be put on the Web in early 2003.

Publications of the CASCA project

Scientific articles published in 2002 in international journals and proceedings of international conferences:

Vaast Ph., Génard M., **Dauzat J.** (2002). Modeling the effects of fruit load, shade and plant water status on coffee berry growth and carbon partitioning at the branch level. In the proceedings of the Sixth International Symposium in Fruit Research and Orchard Management. Acta Horticulturae. 584:57-62.

Vaast P., **Harmand J.M.** (2002). Importance des systèmes agroforestiers dans la production de café en Amérique centrale et au Mexique. Plantations, recherche, développement, (published Sept. 2002)

Scientific articles submitted or accepted in 2002

Bertrand R, Etienne H., **Vaast** Ph., and **Guyot B.** (2002). Leaf to fruit ratio and light environment inthe *Coffea arabica* canopy influence bean characteristics and beverage quality. HortScience (accepted Sept. 2002).

Reina Vanessa Renderos Duran, Jean-Michel Harmand, Francisco Jiménez, Donald Kass (2002). Sistemas agroforestales café-eucalipto *(Eucalyptus deglupta)* y contaminaci6n deI agua con nitratos en microcuencas de la Zona Sur de Costa Rica. Agroforesteria en las Americas (accepted Sept. 2002)

Rosenqvist, E., Ottosen, CO., **Vaast Ph.** (2002). Effects ofshade and fruit load on gas exchange characteristics of coffee *(Coffea arabica* L.) cv 'Costa Rica 95' in field conditions. Tree Physiology (submitted Oct. 2002).

Vaast, P., Bertrand B., Génard M. (2002). Fruit load and shade affect improve coffee bean characteristics and beverage quality. Tree Physiology (submitted Oct. 2002)

Van Kanten R. Vaast Ph. (2002).Mediciones de flujo de savia en un ensayo agroforestal de *Coffea arabica* con *Eucalyptus deglupta* o *Terminalia ivorensis* en el sur de Costa Rica. Agroforesteria en las Americas (accepted Sept. 2002).

Siles P. and Vaast Ph. (2002). Comportamiento fisiol6gico deI café asociado con *Eucalyptus deglupta*, *Terminalia ivorensis* y sin sombra. Agroforesteria en las Americas (accepted Sept. 2002).

Chapters of books submitted or accepted in 2002

Eduardo Somarriba, Celia A. Harvey, Mario Samper, Francois Anthony, Jorge GonzaJez, Charles Staver and Robert Rice (2003) Conservation of biodiversity in neotropical coffee *(Coffea arabica)* plantations. In. Agroforestry and Biodiversity Conservation in Tropical Landscapes, Eds. G. Schroth, G. Fonseca, c.A. Harvey, C. Gascon, H. Vasconcelos and A.M.N. Izac. Island Press, Washington, USA. In press.

Masters Thesis (published in 2001 & 2002)

Nougadere, A., Guezennec S. (2002). Diagnostic Agro-économique d'une Région Caféière d'Altitude; Province d'Alajuela, Costa Rica. Rapport de mémoires. CNEARC. Montpellier, France.

De Miguel S. (2002). Dynamique de la biomasse de différents systèmes agroforestiers caféiers dans la zone Sud du Costa Rica. ENGREF, Montpellier, France.

Reina Vanessa Renderos Duran. (2001). Efecto de sistemas agroforestales café-*Eucalyptus deglupta* sobre la contaminaci6n deI agua con nitratos en microcuencas de la Zona Sur de Costa Rica. CATIE Turrialba, Costa Rica.

Jobert Angrand (2002). Floraci6n, desarrollo vegetativo y fotosintesis de *Coffea arabica* L. en diferentes sistemas de cultivos en Pérez Zeled6n y Heredia, Costa Rica. CATIE Turrialba, Costa Rica.

Actual Partitioning of months IWP/PARTNER for the FIRST YEAR of CASCA

Actual Partitioning of months IWP/PARTNER/for the FIRST YEAR [1]

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Done in Year 1	Planned for Year 1
CIRAD											
Total Permanent staff	0,25	5,94	5,3	2,75	1,3	1	2	0	2,09	20,63	18,75
Graduate students		0	5,9	0	0		10,9			16,80	10
Total CIRAD	**0,25**	**5,94**	**11 ,2**	**2,75**	**1,3**	1	**12,9**	**0**	**2,09**	**37,43**	**28,25**
Total CEH	**0**	**0**	**0,12**	**1,47**	**0**	**1,42**	**0,5**	1	**0**	**4,51**	**6,6**
CATIE											
Total Permanent Staff	2	8,5	2	0	10	0	0,5	1	1	25	25
Total Hired Staff	0	7	12	16	6,4	0	0	0	0	41,4	44
Total CATIE	2	**15,5**	**14**	**16**	**16,4**	**0**	**0,5**	1	1	**66,4**	**69**
IICA-PROMECAFE											
Total Permanent staff	2	0,5	2	2,5	2,5	0	0	2	1	10,5	18
Hired staff	0	0	2	1,5	0	0	0	0	0	3,5	26
TotalIICA	2	**0,5**	4	4	**2,5**	**0**	**0**	2	1	**14**	**44**
UNA											
Total Permanent staff	3,25	0	4,25	0	3,5	0	1,75	1,25	1	15	14
Graduate students & hired Staff	4	0	1,3	0	1,3	0	4	0	0	10,6	16
Total UNA	**7,25**	**0**	**5,55**	**0**	**4,8**	**0**	**5,75**	**1,25**	1	**25,6**	**30**
Grand TOTAL	**11 ,5**	**21 ,94**	**34,75**	**23,99**	**25**	**2,05**	**19,15**	**5,75**	**5,09**	**147,94**	**177,85**

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Management Annuai report
Dr. Phili e Vaast (CIRAD), Coordinator

Two workshops were held during this first year, one at the beginning of the project (November 26-30 of2001) in the headquarters of CATIE in Turrialba, Costa Rica and a second one (October 23-30 of 2002) in the headquarters ofUNA in Managua, Nicaragua.

These two workshops were attended by representatives of aIl partners and by researchers from aIl the work-packages. A total of25 **persons** attended the first meeting, representing the 7 associated institutions. A total of **21 persons** attended the second meeting. They have helped in selecting the target coffee agroforestry systems to be studied during the duration of the proj ect:

1) Tirnber species : *Eucalyptus deglupta, Cordia alliodora, Cedrela odorata, Terminalia amazonia* and *Terminalia ivorensis ;*
2) Service species: *Inga* sp., *Erythrina poeppigiana* and *Gliricidia sepium.*

In between these two plenary workshops, technical meetings were held in March and April 2002 in Nicaragua and Costa Rica in order to confirm the choice of coffee and tree associations, to select the field research sites and to refine methodology for field measurements as weIl as to design field questionnaires for socioeconomic surveys.

Two technical are planned in 2003; one between in April 2003 in Guatemala between leaders ofWP1 & 6 &7 to initiate socioeconomic surveys in this country, and a second in June 2003 in Montpellier, France, between leaders ofWP2 & 3 &6 to refine the modeling approach at the plot level.
A consortium meeting is planned for the second week ofNovember 2003 at the headquarters of CATIE in Turrialba, Costa Rica

Months of activities

With the exception ofresearchers from IICA-Promecafé (ANACAFE in Guatemala), aIl project partners have had an important input in terms oftime spent on the activities dedicated to the project. Out of the **177.9 months initially planned** for the first year, **147.9 months have been dedicated** to CASCA activities (see details ofmonths of activities per partner in annexes). The deficit is mainly due a low hiring of temporary workers on the part ofIICA-Promecafé in the absence of field activities in Guatemala and the difficulties encountered by UNA in Nicaragua to hire outside personnel due to internaI administrative procedures.

Financial aspects

Purchase of equipment has been delayed and not fu11y completed by the end of the first year for most of the CASCA partners due to various reasons. These delays are mainly due to late reception of UB funds and cumbersome internaI procedures (a minimum of 3 quotes per equipment no older than a month for both UNA and rrCA, and the obligation to purchase form an accredited national enterprise for UNA). The remaining of these scientific equipments has been ordered by a11 partners and should be available in early 2003 before the start of the new coffee producing cycle.

Due to the purchase of costly scientific equipments and a vehicle for the project, CATIE has asked and has been granted by the B.U administration an additional advance of 40 000 euros to coyer the needs for field research activities.

Two partners of CASCA, UNA and CATIE, would like to see funds re-allocated from Personnel to Travel and Subsistence. This is due to the fact that these two institutions rely mainly on permanent technicians and students to do a large part of the fieldwork and less than previously planned by hired workers. Furthermore, the localization of many experimental sites is often at several hundred kilometers from their headquarters and this results in important expenses for travel and lodging. An officialletter will be send on their behalfby the coordinator to address these issues with the B.U administrative officer in charge of CASCA.

Out of the fIfSt total advance of 258 969 euros transferred by the B.U. in Febmary 2001 and October 2002, a total of 209 293,72 Euros have been justified in the cost statements of the first project year by the CASCA partners fo11owing the repartition below:

Acronyms contractors	Advance	Date of transfer	FI/llds jl/stijied Elld of 1` year	Balallce at Elld of 1` year
CIRAD	68 147,00	08/02/02	59018,85	9 128,15
NERe.CEH.ERS	35400,00	15/05/02	28986,27	6401,92
CATIE.ACSAF	111 422,00	05/02/02	95265,05	16 156,95
IICAGT.PRCAFE	29227,00	08/02/02	15450,49	13 776,51
UNA.ARNA	14773,00	05/02/02	10561,25	4211,75
Total	258 969,00		2_0_9_2_8_1,9_1	49 687,09

Finally regarding these fmancial aspects, it is worth mentioning that it is not known by CASCA partners when and what amount to expect from the E.U for the second year due to difficulties in understanding the prevailing mIes of funds allocation.

Educational aspects

An important achievement of CASCA is the opportunity given to 14 graduate students to undertake their research activities with technical and financial support of the project.

Five students from UNA have done their research works with the help of CASCA in order to obtain their diploma in agricultural engineering. Three European students (2 French and one Spanish) have spent more than five months each doing their fieldwork in Costa Rica for their Masters. One doctoral student from CIRAD has spent 3.5 months in Costa Rica initiating his research and will come back for 8 months in 2003. Five students (4 in Masters and one Doctoral) of CATIE have done their fieldwork in Costa Rica as part of their degree requirements. A researcher of CATIE has spent 5 months in CIRAD, Montpellier, to develop a first draft of a light partitioning mode!.

Exploitation and Dissemination

Three scientific publications have been submitted to international journals (see annexes ofWP2 and WP3). **One article** has been published in proceedings of an international symposium. An **article** has been published in Plantation, Recherches et Developpement to present the project to a large audience in French and English (with a summary in Spanish). Three have been submitted in 2002 in Spanish in ajournaI ofregional importance (Agroforesteria en Las Americas). **One chapter** will be published in early 2003 in a book untitled "Agroforestry and Biodiversity Conservation in Tropical Landscapes".

Four theses will be published before the end of 2002.

Three oral presentations of the objectives ofCASCA have been performed during **coffee congresses** and workshops **in Costa Rica, Guatemala and Nicaragua.**

A **brochure** is in preparation for the **Salon International d'Agriculture** to be held in Paris, France, from February 22nd to March 3rd 2003 with the objective to present the CASCA project to the general public and the European coffee sector.

CENTRE de COOPERATION en RECHERCHE AGRONOMIQUE pour le DEVELOPPEMENT

CIRAD

ANNUAL REPORT of ACTIVITIES for the INCO PROJECT

CASCA

1[ST] YEAR (NOV. 2001- OCT. 2002)

Dr. Philippe Vaast

NOVEMBER 2002

INTRODUCTION

The project "Coffee Agroforestry Systems in Central America" with acronym CASCA, financed by the European Union, officially started on November 1st of 2001 with duration of four years. The objective of the present report is to highlight the main activities undertaken by CIRAD, as coordinator of the project, during the first year (November 2001 - October 2002).

A total of 10 permanent CIRAD researchers were involved in the project for a total of 20.63 months with 2.1 months dedicated to technical and administrative coordination. Three students, hired temporally, were involved in field research for a total of 16.8 months. This results in a CIRAD input of 37.43 months of work compared to the 28.75 months planned (see annex)

This report of activities is presented by Work-packages.

Work-Package 1: (Central American coffee agroforestry knowledge)

The main objective of this WP1 is collecting and analyzing data on farmers' agroforestry knowledge, over the first 24 months of the project, in major coffee-growing ecological zones of the 3 countries (Costa Rica, Nicaragua & Guatemala) considered in the project.

As a partner ofthis WPl, CIRAD (Dr. Philippe Bonnal) was involved in designing the questionnaires for field surveys on farmers' strategies in terms of coffee cultivation and agroforestry practices. Two students hired by CIRAD, originating from CNEARC, France, were involved in collecting data in one region of Costa Rica.

Work-Package 2: (light and water partitioning at plot scale)

The main objective of this WP2 is assessing light and water partitioning between coffee and associate tree in a few target coffee AF systems of regions with distinct agro-ecological conditions.

As leader of this WP2, CIRAD (Dr. Jean Dauzat) has been involved in designing field methodology to quantify shade in 4 coffee AF systems, collecting data on light interception by the trees and the development of a model simulating light partitioning between the associate tree and the coffee stratum (see WP2 report for more details).

CIRAD (Dr. Philippe Vaast) has also been strongly involved in designing field methodology to collect data on transpiration of both coffee and tree strata using sap flow measurements and tutoring a Ph.D student of CATIE (see WP2 report for more details).

Work-Package 3: (coffee ecophysiology and quality)

The main objectives of this WP3 are studying physiological responses of coffee leaves to micro-environmental field conditions, developing a model of carbon production and allocation in coffee plants as well as investigating the mechanisms responsible for coffee quality.

As leader ofthis WP2, **CIRAD** (Dr. Philippe Vaast) has been involved in **quantifying carbon allocation between fruit and shoot, leaf and fruit photosynthesis, stomatal conductance and photo-inhibition due to high solar radiation** in optimal ecological conditions for coffee growth and production on the experimental station of CrCAFE, Central valley, Costa Rica. AlI these measurements have been used to parameterize a carbon model at the branch level (see WP2 report for more details). One article has been published in 2002 in Acta Horticultura (see annex). Two articles for international journals are in preparation.

CIRAD has also been involved in **quantifying the effects of shade and fruit load on the quality of coffee** in terms of physical (bean size) biochemical (saccharose, fat content,.. etc) and organoleptic (acidity, bitterness, preference) properties. More than 200 analyses (biochemical and tasting) have been performed by CIRAD (B. Guyot and J.1. Perriot) in its laboratory in Montpellier. One article has been accepted for publication in 2002 in Horticultural Science (see annexes). One has been submitted in October 2002 (see annexes). Most relevant results are exposed in WP3 report.

CIRAD (Dr. Philippe Vaast and Nicolas Franck) have designed and installed in a commercial coffee field, Orosi, Costa Rica, a trial to test different levels of shade on coffee physiology and where intensive measurements will be undertaken in 2003.

Work-Package 4: (Nitrogen cycling, leaching, uptake and emissions)

The main objectives ofthis WP4 are to **measure nitrogen** (N) **fluxes** in a few target coffee management systems, **to model N cycling** in order to **predict the N** losses **and accumulation,** and to carry out environmental evaluation at catchment's scale.

As leader ofthis WP4, CrRAD (Dr. Jean-Michel Harmand) has been strongly involved in **designing field methodology to quantify N fluxes** in two agroforestry systems. Studies began with CATIE in Costa Rica in a coffee plantation shaded by *Eucalyptus deglupta* with medium fertilizer input and an organic coffee system shaded by a legume tree.
Two study designs on N fluxes were elaborated for the attention of our partners: CrCAFE (Costa Rica) and UNA (Nicaragua). CIRAD contributed to **collecting data** on N **mineralization, N accumulation in the soil profile** depending on intensities ofN fertilization and management, **losses via leaching and nitrous oxide emissions** in 3 coffee AF (see WP4 report for more details). These studies will also provide results for WP2 (water cycling) and WP5 (C sequestration).

Robert Oliver took in charge a lot ofN analyses in his laboratory in CIRAD in Montpellier. He visited CATIE in May 2002 in order to install the Nitrogen analyzer bought by CATIE with CASCA funds and to teach the person in charge of the equipment about its functioning.

Work-Package 5: (carbon sequestration)

The main objectives of this WP5 are to **measure carbon sequestration** in biomass and soil of a a few target coffee AF systems, to **create a database** of C sequestration in coffee AF systems in Central America, and to **develop a model** predicting C sequestration at the site scale and regional scale.

CIRAD (Dr. Jean-Michel Harmand) is sharing the coordination ofthis WP5 with CATIE (Dr. Markku Kanninen), originally the sole leader of this WP.

CIRAD has been strongly involved in **measuring biomass** of coffee and *Eucalyptus deglupta* in two plantations in the southem lowland part of Costa Rica. Characteristics (height, crown projection, diameter at breath high) and biomass of *Eucalyptus deglupta* in coffee plantations of 2, 4, 6 and 7 years were performed to obtain **allometric relationships.** Biomass of coffee trees was also quantified as weIl as that of leaf fall and soillitter (see WP4 report for more details). One **graduate student** in forestry from ENGREF, France, undertook his research works in the experiments. He will be defending his thesis in December 2002.

Work-Package 6: (integrated plot modeling)

Like other partners, CIRAD has contributed indirectly to this WP by collecting field data on coffee and tree biomasses that will be used for the model currently being developed by the WP leader, Dr. Marcel van Oijen (see report of WP6).

Work-Package 7: (economic modeling at Carm scale)

As leader ofthis WP7, **CIRAD** (Dr. Philippe Bonnal) has been involved in the elaboration of questionnaires and the supervision of 6 students in the field in Costa Rica and Nicaragua. An economic model has been developed to allow estimation of farmers' revenues according to farm size and management (see report of WP7). Two graduate students in tropical agriculture from CNEARC, France, conducted surveys in the central region of Costa Rica. They have defended their theses in early October 2002.

Work-Package 8: (regional up scaling and policies)

CIRAD has contributed to this WP through discussions with the WP leader (Dr. Gerry Lawson of CEH) and during the two meetings held during the first year of CASCA. Furthermore, two researchers (Dr. Philippe Vaast and Dr. Jean-Michel Harmand) ofCIRAD have been involved in the development of the methodology for a study to assess beneficial effects of coffee agroforestry management on water quality and to value these environrnental services; this study will be undertaken in Guatemala in early 2003.

Work-Package 9: (project management, dissemination, and exploitation)

As leader ofthis WP9, **CIRAD** (Dr. Philippe Vaast) has been co-organized the **initial meeting** ofCASCA in late November 2001 at CATIE headquarters in Costa Rica and the **second meeting** in late October 2002 at UNA headquarters in Nicaragua.

As coordinator, CIRAD (Dr. Philippe Vaast and Ms Catherine Potvin) has produced the **6-month report** of activities as weIl as this **present technical and the annual financial report** with the collaboration ofpartners.

Through **scientific publications** (see annexes), CIRAD has also contributed to the exploitation and dissemination ofresults. Three **oral presentations** of the objectives of the projects have been performed during **coffee congresses** and workshop **in Costa Rica, Guatemala and Nicaragua. An article** has been published in Plantation, Recherches et Development to present the project to a large audience in French and English (with a summary in Spanish). A **brochure** is in preparation for the **Salon International d'Agriculture** to be held in Paris, France, from February 22nd to March 3rd 2003 with the objective to present the CASCA project to the general public and the European coffee sector.

A **Cdrom** is in preparation, recollecting aIl the presentations done by partners and WP leaders during the two CASCA meetings; this CDrom will be distributed to aIl partners and representations ofE.U in countries. A **website in spanish,** to be hosted by CATIE, is also in development and should be put on the Web in early 2003.

Sub-contracting

The sub-contractor INRA (Institut National de la Recherche Agronomique) has been involved in the project through a visit to Cost Rica (10-16 March 2002) and exchanges of emails. The visit to Costa Rica has permitted to Dr. R. Toumebize to leam about coffee agroforestry systems in the Central American region, to present and share bis experience in terms of sap flow measurements and research on tree association with crops, and to present the model STIC developed by INRA in order to simulate and diagnose the function.ing of crops in association (see annexes). Dr Etienne Dambrine from INRA, Nancy, was also strongly involved in designing methodology for nitrogen and carbon studies during the first year of the project. Purchase, field application and analyses of N_{15} have been rescheduled for 2003.

ANNEXES

Publication of CIRAD

Scientific articles (submitted, accepted or published) in international journals

Bertrand B., Etienne H., **Vaast** P., and **Guyot B.** (2002). Leaf to fruit ratio and light environrnent inthe *CofJea arabica* canopy influence bean characteristics and beverage quality. HortScience (accepted Sept. 2002).

Vaast P., Bertrand B., Génard M. (2002). Fruit load and shade affect improve coffee bean characteristics and beverage quality. Tree Physiology (submitted Oct. 2002)

Vaast P., **Harmand J.M.** (2002). Importance des systèmes agroforestiers dans la production de café en Amérique centrale et au Mexique. Plantations, recherche, développement, (published Sept. 2002)

Vaast Ph., Génard M., **Dauzat J.** (2001). Modeling the effects of fruit load, shade and plant water status on coffee berry growth and carbon partitioning at the branch level. In Symposium on Modeling of Ecophysiological Processes in Fruit Trees. Acta Horticulturae (published August 2002)

Rosenqvist, E., Ottosen, CO., **Vaast** P. (2002). Effects ofshade and fruit load on gas exchange characteristics of coffee *(Coffea arabica* L.) cv 'Costa Rica 95' in field conditions. Tree Physiology (submitted Oct. 2002)

Thesis (published in 2002)

Nougadere, A., Guezennec S. (2002). Diagnostic Agro-économique d'une Région Caféière d'Altitude; Province d'Alajuela, Costa Rica. Rapport de mémoires. CNEARC. Pp 99.

De Miguel S. (2002). Dynamique de la biomasse de différents systèmes agroforestiers caféiers dans la zone Sud du Costa Rica. ENGREF Montpellier.

Presentations

Three oral presentations of the general objectives of the project have been performed during coffee congresses and workshops in Costa Rica, Guatemala and Nicaragua.

Poster

One poster "Ventajas y desaventajas de los arboles de sombra en sistemas agroforestales con café en CentroAmerica" presented in **5 coffee congresses in Central America.**

Institut National de la Recherche Agronomique

COMPTE RENDU DE MISSION

PAYS VISITE(s): COSTA RICA

DUREE: Du 10/03/2002 Au 16/03/2002

ORDRE DE MISSION N°202 / 135

IDENTIFICATION DU MISSIONNAIRE

NOM, Prénom, Grade: TOURNEBIZE, Régis, CR2
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Intitulé de l'Unité: UR Agropédoclimatique
Centre de recherches :Antilles- Guyane
Département de recherches :Environnement-Agronomie

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**(Privilégier la présentation sous forme de tableau en cas de correspondants multiples et développer les sigles).*

THEME(S) ET üBJECTIF(S) DE LA MISSION

1 : Dans le cadre du projet européen CASCA faire valoir de l'expérience de l'unité sur la mesure des flux de sève et sur l'estimation du bilan hydrique d'une association agroforestière café/arbres
2 : Connaître par des visites sur place les différents types de systèmes de cultures du café et les lieux d'expérimentations possibles
3 : Présenter le modèle SnCS cultures associées comme outil de simulation et de diagnostic du fonctionnement des cultures associées.

Mots-clefs: café, cultures associées, flux de sève, bilan hydrique, modélisation, coopération régionale.

POINTS ESSENTIELS

1- Pour vous et vos collègues du département
2- Pour la politique de l'INRA
3 - Personnalités remarquables rencontrées
4 - Propositions de coopération à venir

-1- Partage de notre savoir faire : - Modèle de production STICS (Toumebize, Brisson) - Mesure des flux de sève
-4- Envisager le prolongement de cette collaboration par le financement et le co-encadrement d'une thèse

INRA Centre Antilles-Guyane, Unité Agropédoclimatique de la Zone Caraïbe
Domaine Duclos 97170 PETIT-BOURG (Guadeloupe, France) ☎ 590. 25.59.74 - fax: 590.94.16.63

NB : En cas de mission groupées donnant lieu à une compte rendu commun, remplir une page par missionnaire. Il n'est pas interdit à chacun de développer des points essentiels différents.

Compte rendu de Mission au Costa Rica
Du 10 au 16 mars 2002

Cette mission s'inscrivait dans le cadre du projet CASCA (Coffee Agroforestry Systems in Central America) ou notre unité est sous-contractante pour la mesure et la modélisation des flux d'eau du café associé ou non.

Cette mission est la première d'une série de 2. Elle a permis:

de prendre connaissance du projet CASCA et des premières rencontres de Novembre (Annexe 1)

de présenter les travaux développés dans l'unité autour du modèle SncS Cultures associées

d'aider au suivi et au traitement des mesures de flux de sève, et plus généralement de prendre connaissance des différents systèmes de cultures a base de caféiers et de contribuer a la mise au point des mesures qui seront nécessaires à l'établissement du bilan hydrique (voir calendrier de la mission en Annexe 2)

Les objectifs du projet relatif a notre domaine d'intervention sont les suivants:
- établir un bilan hydrique du système caféier associé ou non.
- mettre au point un modèle de production du café associé ou non

Le travail a consisté outre la visite de différents types et sites de cultures du café dans le pays, à aborder la particularité du bilan hydrique dans de tels systèmes . Nous avons par exemple noté l'importance relative de la rosée qui perdure une heure de plus dans le système associé par rapport au café cultivé en pur, ainsi que l'importance de l'interception de la pluie. Ces considérations permettront également de valoriser les travaux d'interception/redistribution de la pluie développés au sein de l'unité par F Bussière sur le bananier.

Pour les mesures in situ, l'utilisation de matériel Campbell et Dynamax (que nous connaissons et utilisons également) permet d'envisager facilement un appui à la programmation et au traitement des données. De plus l'utilisation de matériel de même marque rend le prêt aisé ce qui pourra permettre d'augmenter le nombre de mesures ou le nombre de sites équipés au Costa Rica dans un premier temps comme en Guadeloupe par la suite.

Les différentes séances de travail on également permis de présenter le modèle SncS, déjà fonctionnel pour les cultures associées. Ce modèle comporte déjà un module relatif au gliricidia, que nous avons paramétrer et valider dans le cadre de cultures fourragères, et qui pourra donc facilement être transposé au système café/gliricidia utilisé notamment au Nicaragua.

La similitude de nos approches sur ces systèmes de cultures associées et nos avancées en matière de modélisation permettent d'or et déjà , et au delà du contrat CASCA d'envisager le développement de nos collaborations par le dépôt de dossier de coopération (ECOS) ainsi que par une demande de bourse de thèse. Ce travail co-encadré sur les systèmes de cultures caféiers associés pourrait alors servir la grande caraibe et la Guadeloupe en particulier.

CALENDRIER DE LA MISSION

Dimanche 10 Mars
Transfert Pointe Pitre (7HOO) San José (21H00)
Lundi 11 mars
Catie, discussion générale autour du projet CASCA et des compétences de l'Equipe APC
Mardi 12 *mars*
Visite des sites VerdeVigor (suivi des flux de sève)
Mercredi 13 *mars*
Suite flux de sève et visite du site Santa Fé, début de présentation de Stics
Jeudi 14 *mars*
Catie, discussion suite
Visite café biologique (Para Iso)
Vendredi 15 *mars*
Visite Sicafé, discussion, présentation de Stics, Synthèse
Samedi 16 *mars*
Départ San José 7H20 Arrivée Pointe a Pitre 21H10

Planned Partitioning of months !WP/PARTNER/for the FIRST YEAR

Person-monthslYear

CIRAD	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Yr1
Total Permanent staff	0,25	3,5	3,5	2,25	1	0,5	3	0,25	2,00	18,75
Students		5,00	5,00	o	o		o			10,00
Total CIRAD Yr1	0,25	8,50	8,50	2,25	1,00	0,50	3,00	0,25	2,00	28,75

Actual Partitioning of months !WP/PARTNERlfor the FIRST YEAR

CIRAD	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Yr1
P Vaast scientific & adm. Coordination									1,05	1,05
C. Potvin Administrative coordination									1,05	1,05
P.Vaast		0,88	2,5			0,5				3,88
JM Harmand		1,33		2	1,3					4,63
J. Dauzat		1,98	0,5			0,5				2,98
N. Franck (Post-doc)		1,75	1,8							3,55
B.Guyot			0,25							0,25
JJ. Perriot			0,25							0,25
P. Bonnal	0,25						2			2,25
R.üliver				0,75	o					0,75
Total Permanent staff	0,25	5,94	5,3	2,75	1,3	1	2	0	2,09	20,63
Students		o	5,9	o	o		10,9			16,80
Total CIRAD Yr1	0,25	5,94	11,2	2,75	1,3	1	12,9	0	2,09	37,43

CASCA Project

Contractor NERC (Centre for Ecology and Hydrology)

First Year Report

1. Participant number, name and address of the participating organisation

Contractor 3 (NERC - Centre for Ecology & Hydrology)

Centre for Ecology and Hydrology - Bush Estate Penicuik, Midlothian EH26 OQP

2. Scientific team

Name.	Tel	Fax	E-mail
Mr Gerry Lawson	44 131 445 8549	44 131 445 3943	gjl@ceh.ac.llk
Dr Marcel van Oijen	44 131 445 8567	44 131 445 3943	mvano({ùceh.ac.uk
Dr Ute Slciba	44 131 445 8532	441314453943	ums@ceh.ac.uk
Prof Melvin Cannell	44 131 4458503	441314453949	mgrc@ceh.ac.uk

G.J. Lawson BSc M1CFor is a systems ecologist and Chartered Forester with European agroforestry experience dating from 1982 and tropical agroforestry experience (mainly Africa) from 1989. He co-ordinated the UK-DFID Agroforestry Modelling Programme, TIGER (a NERC programme on global environmental change), and has developed interaction models for agroforests and mixed tropical forests. He has experience with landscape classification in Europe and socio-economic modelling of household survey data from Ghana.

Professor Melvin Cannell DSc. 1s a Fellow of the Royal Society of Edinburgh and the Institute of Chartered Foresters. He moved to Kenya in 1966 to do research on coffee, and from there to the Edinburgh Station of the Centre for Ecology and Hydrology, where he is now Head. His research interests are in the physiology and genetics of trees of aU kinds - temperate conifers, energy crops, agroforests, plantation crops and tropical rainforests. He has undertaken numerous consultancies since 1974 including: tea research in Kenya and Malawi; forestry research in the USA, including a year spent with the Weyerhaeuser Company; biophysical research at the International Centre for Research in Agroforestry (ICRAF), Kenya; and future research strategies on short-rotation biomass plantations for the EC and agroforestry modeUing for DFID

Dr Ute Skiba is a soil microbiologist scientist with I1 years experience in investigating trace gas emissions from soils, principaUy NO and NzO emissions, microbial processes and the main variables involved in controUing the fluxes and scaling to regions.

Dr Marcel van Oijen has worked as a modeller of plant and crop processes in Wageningen University and Research Center (The Netherlands) from 1985 to 1999. He developed growth models for the effects on plants of the abiotic environment (light, temperature, C0 2, water- and N- availability, ozone) and weeds, pests and pathogens. In 1999, he moved to the Centre of Ecology and Hydrology in Edinburgh where he focuses on the effects of climate change and N-availability on forest growth.

3. Time spent on the different workpackages

Time (months) spent on the different workpackages during the first year

Name	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	Total	Total yr1
Total Allocation			2.1	3.9	0.7	7.8	1.7	2.8	18.9	6.6
Mr Gerry Lawson						0.29	0.5			1.79
Dr Marcel van Oijen						1.13				1.13
Dr Ute Skiba				1.47						1.47
Prof Melvin Cannell			0.12							0.12
Total										4.51

Total time spent (4.51person months), is somewhat less than planned in Year 1 (6.6 months), but realistic given the total allocation over 4 years (18.9 months).

4. Contribution to workpackages:

4.1. WP1. Central American Coffee Agroforestry Knowledge

4.2. WP2 Light and Water partitioning at plot scale

4.3. WP3 Coffee ecophysiology and quality

(Total allocation 2.1 months, spend in year 1 = O12months)

Melvin Cannell has made a small input on coffee ecophysiological processes to the modelling effort of Marcel van Oijen. His long-term experience in this area is summarised in a number of papers on carbon allocation in trees and coffee plants in East Africa contributed to the Project bibliographic database.

4.4. WP4 Nitrogen cycling, leaching, uptake and emissions

(Total allocation 3.9 months, spend in year 1 =1.47months)

The effort ofUte Skiba in this first year has principally been devoted to designing, making and installing measurement chambers for N_20 flux measurement at 3 sites in Costa Rica. She visited Costa Rica on 17-22nd June 2001 and made N_20 measurements from a number of treatments in Heridia, Paraiso and Santa Fe. Seasonal analyses of N_20 have been made on air samples returned to Edinburgh on 3 occasions through the year. Summary conclusions include: a) N fertiliser additions stimulate N20 emissions, but soil type and rainfall patterns appear to be equally important in controlling emissions and N losses; b) the effect of shade trees on N20 emissions and N loss is inconclusive; c) denitrification losses from organic and conventional systems can be equally large. For further information see the WP3 report.

4.5. WP5 Carbon sequestration

(Total allocation 0.7 months, spend in year 1 =0 months)

4.6. WP6 Integrated plot modelling

(Total allocation 7.8 months, spend inyear 1 =1.42 months)

Marcel van Oijen attended the first CASCA workshop from at Turrialba, Costa Rica, from 26-30th November 2001 and the second workshop in Managua, Nicaragua from 24-30 October 2002. He has produced a preliminary version of a model in MATLAB/SIMULINK that that can be used to analyse the effects of environmental conditions (weather and soil), competition with tree species, and management decisions (pruning, thinning, planting density) on coffee yield, use of nitrogen and water, and nitrogen leaching. The model is used to simulate interception of light and fluxes of carbon, nitrogen and water between soil, plants and atmosphere. Processes include a) tracking of plant biomass components, phenology, light interception, source sink-dynamics, leaf area growth; senescence; root depth growth, management anagement (pruning, thinning and harvesting), tree shading and competition for resources, soil evaporation and transpiraton, drainage, runoff and irrigation, nitrogen uptake, nitrogen leaching, and clirnatic interactions. See the Workpackage 6 Report for further details.

4.7. WP7 Economie modelling at farm scale

(Total allocation 1.7 months, spend in year 1 =0.5 months)

4.8. WP8 Regional upscaling and policies

(Total allocation 2.8 months, spend in year 1 =1 month)

Gerry Lawson visited Nicaragua and Costa Rica between 21st and 28th April and took part in field visits to potential study sites for the socio-econornic studies (see WP7 report). He helped to design the sarnpling protocol and ensure that these sarnples can be placed in the context of regionally available economic, climatic and soils information. Visits were rnake to the Ministry of Agriculture, Fisheries and Forestry in Managua, and to the National Census Office in San Jose. For forther information see the WP8 report)

5. Significant difficulties or delays experienced during the reporting period.

Other than normal startup delays, and difficulties obtaining regional information on soils and c1imate variability there have been no significant problems experienced.

CENTRO AGRONOMICO TROPICAL de
INVESTIGACION y ENSENANZA

ANNUAL REPORT of ACTIVITIES for the INCO PROJECT CASCA

YEAR 2001 - 2002

NOVEMBER 2002

INTRODUCTION

The project "Coffee Agroforestry Systems in Central America" with acronym CASCA, financed by the European Union, officially started on November Ist of 2001 with duration of four years. The objective of the present report is to highlight the main activities undertaken by CATIE, as partner of the project, during the first year (November 2001 - October 2002).

A total of 8 permanent researchers were involved in the project for a total of 25 months. Five students (4 as Masters students and one doctoral students) and 8 persons, hired temporally, were involved in field research for a total of 41.4 months. This results in an input of 66.4 months of work compared to the 69 months planned (see annex)

This report of activities is presented by Work-packages.

Work-Package 1: (Central American coffee agroforestry knowledge)

The main objective ofthis WPl is collecting and analyzing data on farmers' agroforestry knowledge, over the first 24 months of the project, in major coffee-growing ecological zones of the 3 countries (Costa Rica, Nicaragua & Guatemala) considered in the project.

As a leader of this WP1, CATIE (Dr. Eduardo Somarriba) has coordinated with partners the field surveys undertaken in Costa Rica and Nicaragua (see WPl report). Students conducted surveys of farmers about their strategies in terms of coffee cultivation and agroforestry practices Four students ofUNA undertook surveys in one region of Nicaragua and 2 Students from CNEARC, France, in one region of Costa Rica.
Dr. Somarriba also updated the database on CUITent coffee Agroforestry (AF) practices with the help of a CATIE technician (Mario Cervantes). The Database comprised more than 5 case studies done over the last 10 years in 3 countries of Central America (see WP 1 report).

Work-Package 2: (light and water partitioning at plot scale)

The main objective of this WP2 is assessing light and water partitioning between coffee and associate tree in a few target coffee AF systems of regions with distinct agro-ecological conditions.

As partner of this WP2, CATIE has been involved in quantifying shade in 3 coffee AF systems and their effects on coffee growth and productive potential in the southem low altitude part of Costa Rica. A Masters student has worked for several months registering at 3 periods of the year (final of the dry season, transitional period to the rainy season and during the rainy season) the Photosynthetically Active Radiation (PAR) in 3 AF systems (Coffee associated with either *Terminalia ivorensis,* or *Eucalyptus deglupta,* or *Erythrina poeppigiana)* in comparison to coffee in full sun. The Masters student will be defending his thesis in early December 02 (see annex for abstract). One article is in preparation for publication in 2003 in the Revista Agroforestal de CentroAmerica. The results of these investigations show that coffee receives about 55 to 70 % of full sun under shade of

Terminalia ivorensis and *Eucalyptus deglupta*, respectively (see annex fig1). They demonstrate that coffee grows better under shade trees in the sub-optimal conditions of the study. Coffee produces more in these AF systems than in full sun due to a lower fruit drop over the production cycle (see Annex Table 1).

CATIE has been strongly involved in collecting data on light interception by the trees and the development of a mode) simulating light partitioning between the associate tree and the coffee stratum (see WP2 report for more details).

CATIE has also been strongly involved in collecting data on transpiration of both coffee and tree strata using sap f10w measurements. A Ph.D student has been collected data from December 01 to June 02 as part of his doctoral work; one technician, temporally hired by CATIE, has been following up the collection of these data during the rest of the year 2002. The student will be defending his doctoral thesis in February 03 (see annex for abstract of the chapter). A methodological article on how to perform sap flow measurements in AF systems has been published in 2002 in the Revista Agroforestal de CentroAmerica (title "Mediciones de flujo de savia en un ensayo agroforestal de *Coffea arabica* con *Eucalyptus deglupta* o *Terminalia ivorensis* en el sur de Costa Rica). Severa) tables (2, 3 & 4) present the main results on water consumption of coffee and three associated trees, *Eucalyptus deglupta* or *Terminalia ivorensis*, or *Erytrhina poeppigiana*. More details are presented in the annual report ofWP2.

Work-Package 3: (coffee ecophysiology and quality)

The main objectives of this WP3 are studying physiological responses of coffee leaves to micro-environmental field conditions, developing a model of carbon-allocation in coffee plants as weIl as investigating the mechanisms responsible for cOffee quality.

CATIE has been involved in quantifying coffee fruit growth in 3 coffee AF systems in the southem low altitude part of Costa Rica. A Masters student has worked for several months registering leaf and fruit photosynthesis in collaboration with CICAFE in a field trial in optimal conditions of the central valley of Costa Rica. Destructive samplings of fruiting branches have also been performed to quantify carbon allocation between fruits and vegetative part. One article has been published in 2002 in the Revista Agroforestal de CentroAmerica (see annex for abstract). These results demonstrated that trees create a more favorable microclimate for coffee by decreasing temperature at the coffee leaf level (see Annex Fig 2). They also demonstrate that leaf stomatal conductance and photosynthetic activity are at their highest during the early hours of the day and strongly decrease thereafter (see Annex Fig 3).

Work-Package 4: (Nitrogen cycling, leaching, uptake and emissions)

The main objectives of this WP4 are to measure nitrogen (N) fluxes in a few target coffee management systems, to model N cycling in order to predict the N losses and accumulation, and to carry out environmental evaluation at catchment's scale.

With funds from CASCA, CATIE bought a N analyzer in order to determine nitrate and ammonium contents of soil and water using the colorimetrie method.

CATIE has contributed to this WP through the field work of two Masters students on a study of Nitrogen dynamic and losses (mineralization and lixiviation) in a coffee agroforestry system with *Eucalyptus deglupta* in the southem zone of Costa Rica (see report of WP4 for details). CATIE has also been involved in measurements of nitrous oxide emissions from soil of different coffee AF plantations and coffee in full sun in three ecological zones of Costa Rica (see report of WP4 for details).

Hector Avila (graduate student from CATIE) studied nitrogen fluxes in a coffee system shaded by *E. deglupta.* The inputs (N fertilizer), the outputs (leaching, runoff) and soil N mineralization were measured in arder to understand the interactions between coffee plants and timber trees in term of nitrogen use and environmental impacts.
Martha Gutierrez (graduate student from CATIE) studied in laboratory conditions the effect of different shade tree species on N mineralization and soil N availability.
Rodolfo Mungia (graduate student from CATIE) studied leaf litter decomposition of coffee plants and different shade tree species using the litterbags method in the field.

Work-Package 5: (carbon sequestration)

The main objectives of this WP5 are to **measure carbon sequestration** in biomass and soil of a a few target coffee AF systems, to **create a database** of C sequestration in coffee AF systems in Central America, and to **develop a model** predicting C sequestration at the site scale and regional scale.

CATIE (Dr. Markku Kanninen) was originally the leader of this WP5. Due to his multiple activities as scientific director of the center, Dr. Kanninen has been sharing this responsibility with Dr. Jean-Michel Harmand of ClRAD.

CATIE has contributed to this WP through the elaboration of a database in Access recapitulating all (around Il) studies undertaken over the last 25 years on C flux and accumulation in coffee AF systems in Central America and other coffee-producing countries. This database is accessible via the website of CATIE (see report of WP5 for details). Furthermore, CATIE has contributed through the e1aboration of the Masters project of one of its students. In 2003, this student will survey farmers in 4 regions of Costa Rica and measure in the field the accumulated biomass of 4 timber-tree species in coffee AF systems to look at the effect of farm management and local ecological conditions on tree growth.

Work-Package 6: (integrated plot modeling)

Like other partners, CATIE has contributed indirectly to this WP by collecting field data on coffee and tree biomasses that will be used for the model currently being developed by the WP leader, Dr. Marcel van Oijen (see report of WP6).

Work-Package 7: (economic modeling at Carm scale)

CATIE has contributed to this WP by helping in the elaboration of questionnaires and supervising students in the field in Costa Rica and Nicaragua (see report ofWP1).

Work-Package 8: (regional up scaling and policies)

CATIE has contributed to this WP through discussions with the WP leader and during the two meetings held during the first year of CASCA. Furthermore, one researcher (Dr. Francisco Jimenez) of CATIE has been involved in the development ofthe methodology for a study to assess beneficial effects of coffee agroforestry management on water quality and to value these environmental services; this study will be undertaken in Guatemala in early 2003.

Work-Package 9: (project management, dissemination, and exploitation)

CATIE has contributed to this WP by co-organizing the initial meeting of CASCA in late November 2001 and through the dissemination ofresults via the elaboration of a on-line C database and publications (see annexes).

ANNEXES

Publication of CATIE

Eduardo Somarriba, Celia A. Harvey, Mario Samper, Francois Anthony, Jorge González, Charles Staver and Robert Rice (2003) Conservation of biodiversity in neotropical coffee *(CofJea arabica)* plantations. In. Agroforestry and Biodiversity Conservation in Tropical Landscapes, Eds. G. Schroth, G. Fonseca, C.A. Harvey, C. Gascon, H. Vasconcelos and A.M.N. Izac. Island Press, Washington, USA. **In** press.

Masters Thesis at CATIE 2002

Angrand, Je. 2002. Flowering, vegetative growth and photosynthesis of *CofJea arabica* L. in different culture systems in Perez Zeled6n y Heredia, Costa Rica. 90p.

Abstract

The first part of this research was carried out in Verde Vigor Farm, Perez Zeled6n, Costa Rica, an vegetative growth, flowering and coffee production were evaluated in three agroforestry systems with regard to full sun in Verde Vigor farm. These Agroforestry systems were established with *Eucalyptus deglupta* Blume , *Terminalia ivorensis* y *Erythrina poeppigiana*, respectively. The main objective ofthis research was to contribute to a better understanding of the productive and reproductive behaviors of *CofJea arabica* in these different systems.

Vegetative growth was superior in the agroforestry systems than in full sun. The best performance was under Terminalia followed by Eucalyptus because of a better microclimatic buffering and a lower photosynthetic active radiation (55 to 70 % of full sun). Flower number by productive nod was superior in full sun in comparison to the three agroforestry systems. On the other hand, fruit number by productive nod was superior under *E. deglupta* , then *T. ivorensis,* and then *E. poeppigiana* than under full sun. This is due to a higher rate of fruit drop in full sun (35.7 %) compared to that under *E. deglupta* , *T. ivorensis,* and *E. poeppigiana* (14.8 %, 15.5 % and 28.4 %, respectively). Coffee leaf area was higher when coffee was closer of shade tree., However, distance to the shade tree had no significant effect regarding with flower and fruit number by productive nod and fruit weight. The main effects of the position of branches in the coffee canopy were a superior growth of younger branches part and a higher fruit number by nod closer to the coffee tree top.

In the second part of the present thesis, the effects of coffee fruit load and branch ring-barking were evaluated in CICAFE research farrn in Heredia, Costa Rica. The measurements were carried out at four branch levels in twenty four (24) randomized coffee trees in full sun. The objective ofthis research was to evaluate how the main treatments (coffee fruit load and ring-barking) influenced vegetative growth, leaf and fruit photosynthesis and production. Moreover, the objective was to evaluate the contribution of fruit assimilation to its own t carbohydrate demand. The fruit load did not have any effect on vegetative growth, possibly due to the fact that measurements were performed early in the productive cycle, *i. e.* only five month after coffee flowering. Nevertheless, leaf net assimilation increased with fruit load independently of the PAR level applied. This demonstrated that fruit demand stimulated leaf photosynthesis. With ring-barking of the branch, the leaf area was lower than without ring-barking.. The leafnet assimilation was lower on isolated branch (3.2 µmol CO_2 $m^{-2}s^{-1}$) in comparison with non-isolated branch (4.73 µmol CO_2 $m^{-2}s^{-1}$). For a 300 µmol quantum $m^{-2}s^{-1}$ and without fruit load, the non-isolated branches achieved a level ofphotosynthesis 160% higher than isolated branches (1.70 µmol CO_2 $m^{-2}s^{-1}$ to 4.49 µmol CO_2 $m^{-2}s^{-1}$). This shows that there is a strong effect of carbohydrate demand from other parts of the coffee tree that strongly stimulates the photosynthesis of the branches when they can export their excess product of assimilation. For a PAR of 300 µmol quantum $m^{-2}s^{-1}$ and irrespective of the fruit load, leaf net assimilation was significantly higher in the moming (7:00 - 9:00 AM) with a value of 4.6µmol CO_2 $m^{-2}s^{-1}$) in comparison with later periods during the day 11:00 -13:00 and 15:00-17:00 with values of3.71 and 3.63 µmol CO_2 $m^{-2}s^{-1}$, respectively. Fruit photosynthesis was carried out directly on attached green fruit. The coffee fruit load had a significant effect on fruit photosynthesis for a PAR level of 900 µmol quantum $m^{-2}s^{-1}$. Net assimilation was less negative at a PAR level superior to 300 µmol $m^{-2}s^{-1}$. Ring-barking had a significant effect on the fruit photosynthesis as the net assimilation was less negative on the ring-barking branches than on the non-isolated branches. The different sequences of measurements of fruit photosynthesis showed that fruit photosynthesis increased with increasing PAR. Therefore, it can be conclude that fruit photosynthesis plays an important role in its own supply of carbohydrates. Nevertheless, more studies are needed to improve our understanding ofthese processes.

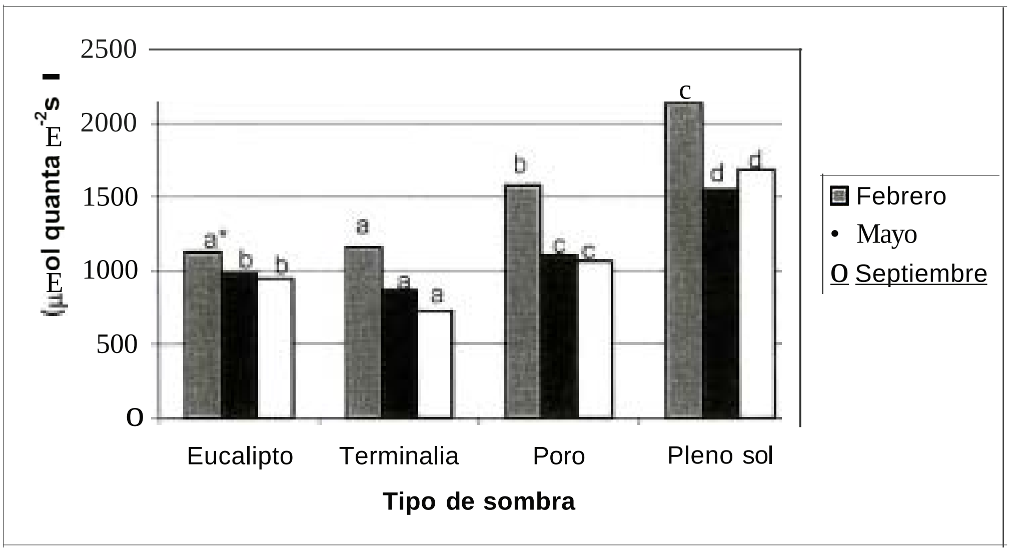

Figura 1. Promedios de radiaci6n fotosintéticamente activa en µmol m-^{2} s-1, bajo Eucalipto , Pora , Terrninalia y Pleno sol en la finca Verde Vigor Pérez Zeled6n , Costa Rica.

Table 1. Promedio de diferentes variables de producci6n deI café a distintos tratamientos de sombreamiento en la Finca Verde Vigor S.A. Pérez Zeled6n, Costa Rica

Variables de producci6n	Tratamiento principal			
deI cafeto	Eucalipto	Terminalia	Poro	Pleno sol
Nudos productivos por bandola	9.0b*	7.5 a	7.4 a	6.7 a
FIor 1 en % flor total	19.0 ab	17.8a	20.0a	25.1 b
Flor2 en % flor total	78.0 a	79.5 a	75.8 a	71.6 a
Flor3 en % flor total	2.9 a	2.7 a	4.2 ab	3.3 ab
Flores / Nudo productivo	9.5 a	9.7 a	9.5 a	10.9 b
Frutos / Nudo productivo	7.6 b	8.0 b	6.3 a	6.2 a
Caida de frutos (%)	14.8 a	15.5 a	28.1 b	35.7 c

Draft summary of chapter from R.F. van Kanten, PH.D student at CATIE

Water uptake by *CofJea arabica* L. and *Eucalyptus deglupta*, *Terminalia ivorensis* or *Erythrina poeppigiana* in coffee agroforestry systems of Southern Costa Rica.
DRAFT: 18 December 2002

Summary

Sap flow was measured simultaneously on evenly aged (3 - 4 yr.) coffee *(CofJea arabica* L.) plants (with Dynagage™ probes) in full sun and associated with timber-trees, *Eucalyptus deglupta* or *Terminalia ivorensis,* or the service tree, *Erytrhina poeppigiana* (with "Granier" probes), during a dry period (January - March) and a wet period (April - July 2002). The mean, daily, coffee water uptake patterns were lower in the dry than in the wet periods, and similar in full sun or undemeath shade trees with lower amplitudes for the coffee associated with the timber-trees. Minimum and maximum daily water uptake varied between 0.29 and 1.73 liter day^{-1} m^{-2} for coffee plants spaced at 1 m x 2 m, between 44 and 119 liter day^{-1} $tree^{-I}$ for the timber-trees *(E. deglupta* and *T. ivorensis)* spaced at 6 m x 6 m and between 13 and 90 liter day^{-1} $tree^{-I}$ for *E. poeppigiana* spaced at 8 m x 8 m. Except for two months under high *T. ivorensis* shade (81 - 84%), Photosynthetic Photon Flux Density values always exceeded the maXImum photosynthetic level required by coffee plants. Air temperature during the day was above 24 oC, and may have reduced coffee transpiration. Neither coffee nor tree water uptake correlated well with ca1culated evapotranspiration. *Eucalyptus deglupta* presented the most consistent tree water uptake pattern. *Terminalia ivorensis* competed the most for water with coffee (January - March and July), and *E. poeppigiana* the least (March). The coffee-E. *poeppigiana* association presented significantly higher soil water content in the first 30 cm as compared to the two other coffee- tree associations. This study emphasizes the need to take water competition into account when selecting a shade tree species in association with coffee. Clearly, coffee productivity, bean quality, farmer strategies and trade-offs of the tree component also deserve consideration.

Key words: agroforestry, air temperature, cofJee, Photosynthetic Photon Flux Density, sap flow, water competition

Table 2. Mean daily accumulated sap flow *(Face)* based on two coffee plants over four consecutive days of every month (litre day^{-1} m-^{2}) in an agroforestry trial (2001 - 2002) in Southem Costa Rica.

Month	Coffee in Full Sun	Coffee with *Eucalyptus deglupta*[1)]	Coffee with *Terminalia ivorensis*	Coffee with *Erythrina poeppigiana*
December	0.74(0.01)a[1)][2)]	0.63(0.03)b	0.47(0.02)c	0.63(0.02)b
January	0.76(0.02)b	0.77(0.02)b	0.S6(0.03)c	0.99(0.02)a
February	0.86(O.04)b	O.39(0.01)c	0.4S(0.01)c	l.08(O.06)a
March	0.S6(0.06)a	0.26(0.02)b	0.24(0.03)b	0.32(0.03)b
April	1.48(0.11)a	O.91(0.07)b	O.87(O.07)b	1.72(0.07)a
May	0.7S(0.07)a	O.61(O.06)ab	0.44(O.OS)b	0.64(O.08)ab
June	0.73(O.10)a	O.67(0.11)a	O.39(0.07)a	O.7S(O.11)a
July	0.79(0.04)b	0.62(0.04)c	0.39(O.01)d	1.01(0.06)a

1) mean (standard error). 2) different letters in the same row indicate differences *(p < O.OS)* by the Student-Newman-Keuls test

Table 3. Mean daily transpiration based on four trees over four consecutive days of every month (litre day-l tree-^{1}) in a trial (2001 – 2002) in Southem Costa Rica.

Month	*Eucalyptus deglupta*	**Terminalia ivorensis**	*Erythrina* ***poeppigiana***
December[1)]	103(3)a[2)][3)]	86(4)b	S2(6)c
Januaryl)	104(3)a	107(11)a	87(9)a
February	63(8)a	7S(6)a	70(6)a
March	56(4)b	44(8)b	90(7)a
April	62(S)a	S7(3)a	13(2)b
May	49(6)a	69(4)a	64(7)a
June	47(7)b	117(17)a	57(8)b
July	S2(8)b	119(13)a	73(4)b

1) means of two instead of four trees. 2) mean (standard error) 3) different letters in the same row indicate differences *(p < O.OS)* by the Student-Newman-Keuls test.

Table 4. Estimation of mean daily water uptake per hectare (m^3 day^{-1} ha-') of coffee alone in full sun or coffee and trees (based on four day periods every month), and the percentage of water used by the coffee plants (C/S) in Southem Costa Rica (2001 - 2002).

Month	Coffee **in Full** Sun[1])	C/S	Coffee **and** *Eucalyptus deglupta*[2])	C/S	Coffee **and** *Terminalia ivorensis*[2])	C/S	Coffee **and** *Erythrina poeppigiana*[3])	C/S
December	6.1	100%	30.9	16.8%	25.4	15.2%	18.2	28.6%
January	6.3	100%	32.4	19.7%	31.4	14.7%	29.9	27.4%
February	7.2	100%	18.7	17.0%	22.5	16.6%	26.4	33.7%
March	4.6	100%	16.4	13.1%	13.0	15.5%	25.1	10.4%
April	12.2	100%	22.4	32.6%	21.5	33.6%	17.4	81.4%
May	6.2	100%	16.8	29.1%	20.9	17.5%	21.3	24.9%
June	6.0	100%	16.6	32.0%	32.5	9.9%	20.4	30.3%
July	6.5	100%	17.2	28.3%	32.9	9.7%	26.6	31.3%

1) 4723 ± 37 (mean ± standard error) coffee plants ha^{-1} in full sun or in association
2) 250 ± 6 *E. deglupta* or *T. ivorensis* trees ha-' 3) 205 ± 6 *E. poeppigiana* trees ha-'

Article published in RAFA 2002

Comportamiento fisiol6gico dei café asociado con *Eucalyptus deglupta, Terminalia ivorensis* y sin sombra

Pablo Siles y Phillipe Vaast

Resumen

Fueron estudiados los cambios diurnos en la época seca y lluviosa de la temperatura foliar, radiaci6n fotosinteticamente activa (RAFA), conductividad estomatica y fotosintesis neta dei café bajo *Eucaliptus deglupta, Terminalia ivorensis* y pleno sol. La humedad dei suelo fue medida por medio de una sonda TOR en la época seca y lluviosa en los sistemas estudiados, mientras la conductividad estomatica de la especies maderables fue medida solamente en la época seca. La humedad dei suelo en la época seca fue menor bajo *T. ivorensis,* 10 que puede estar asociado con mayores tasas de conductividad estomatica en las horas dei mediodfa y de la tarde, esta representa una mayor competencia por agua con los cafetos en la época seca.
En la época lluviosa, no se presentaron diferencias en la humedad dei suelo entre los diferentes sistemas agroforestales. La RAFA y la temperatura foliar tendieron a aumentar hasta alcanzar el mediodfa, después dei cual decrecieron. En las horas de la manana, las plantas bajo pleno sol presentan una temperatura foliar4 oC más altas en comparaci6n a plantas bajo *T. ivorensis*, mientras al mediodfa esta diferencia fue de 2.4 oC. Plantas bajo *E. deglupta* presenta temperaturas 1.9 y 1.5 oC más bajas que plantas bajo pleno sol, en las horas de la manana y mediodia, respectivamente.
La tasa de asimilaci6n neta de CO_2 muestra un patr6n similar bajo pleno sol y *E. hdeglupta,* ya que las maximas tasas se realizan en la manana y disminuyen a 10 largo dei dia. Sin embargo bajo *T. Ivorensis,* las mayores tasas de asimilaci6n se alcanzan en las horas dei mediodfa indicando que la sombra fue muy densa y la RAFA muy baja en las horas de la manana.

Summary

The diurnal changes of the leaf temperature, photosynthetically active radiation (PAR), stomatal conductance and net photosynthesis of coffee growing under *Eucalyptus deglupta, Terminalia ivorensis* and full sun were studied during the dry and rainy seasons. The soil humidity was measured by means of a TOR probe during the dry and rainy seasons in the three studied systems, while the stomatal conductance of the tree species was only measured during the dry season. The soil humidity in the dry season was lower under *T. ivorensis;* this can be associated with higher rates of stomatal conductance of this tree in the midday hours and in the afternoon, this effect represent a higher competition for water between trees and coffee during the rainy season.
Ouring the rainy season, no difference in soil moisture was observed between the different systems. The PAR and the leaf temperature increased until reaching a maximum around noon and decreased thereafter. In the morning hours, plants under full sun present values of leaf temperature 4 oC higher than values presented in plants under T. ivorensis, while at noon this difference was only of 2.4 oC. Plants under *E. deglupta* present values of leaf temperature 1.9 and 1.5 oC lower than plants under full sun at morning and noon, respectively.
The rate of net CO_2 assimilation under full sun and *E. deglupta* had the same pattern; higher rates were observed in the morning hours and assimilation diminished along the day. With *T. ivorensis,* the highest rates of assimilation were only reached around noon due to the high shade density and low PAR received by coffee in the morning hours.

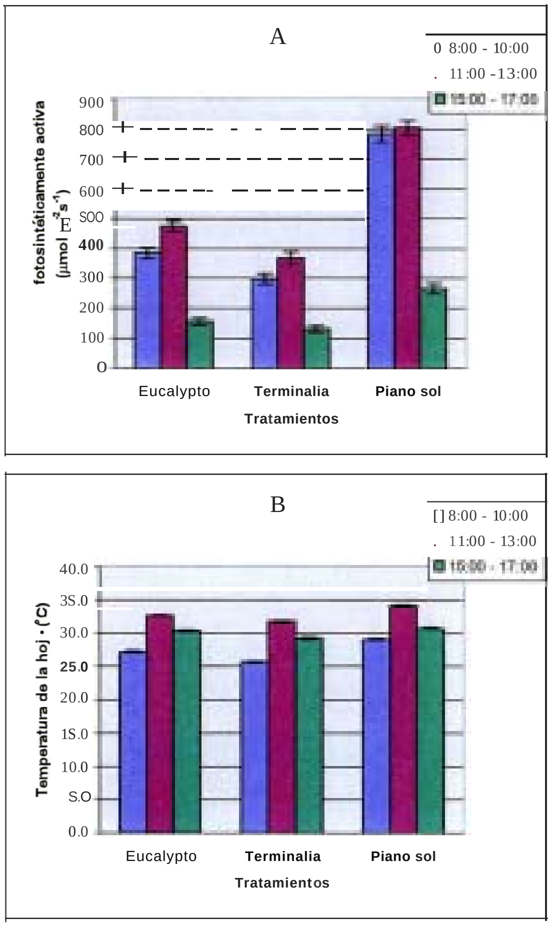

Figura 2. Variables microclimaticas de café bajo diferentes tipos de sombra y horas dei dia. "Verde Vigor', Pérez Zeled6n, Costa Rica.

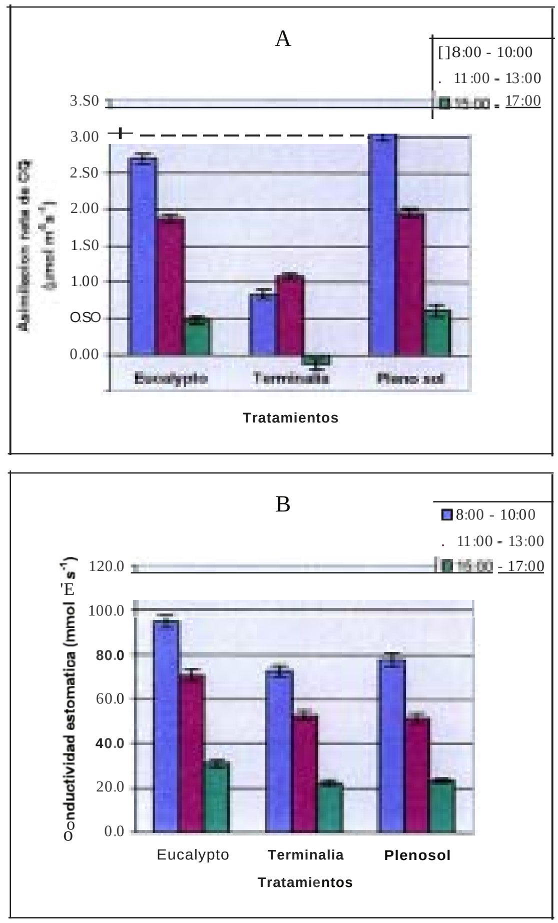

Figura 3. Variables fisiol6gicas de café, afectadas por la interacci6n tipos de sombra y horas dei dia. "Verde Vigor', Pérez Zeled6n, Costa Rica.

Planned Partitioning of months *fWPfP* ARTNERIfor the FIRST YEAR

Partner	WPI	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Yr1
CATIE										
Permanent staff	5	5	5	4	2,5		1,5	1	1	25
Hired staff	7	7	7	7	7		7,5	1,5		44
TOTAL	12,0	12,0	12,0	11,0	9,5	0,0	9,0	2,5	1,0	69,0

Actual Partitioning of months *fWPfP* ARTNERIfor the FIRST YEAR

CATIE	WPI	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Yr1
E. Somarriba	1,5						0,5	0,5		2,5
J. Beer					1					1
F. Jirnenez								0,5		0,5
M. Kanninen					1					1
R. Arguedas									1	1
M. Cervantes	0,5	1,5	2							4
K. Hergoualch					8					8
A. Anzola		7								7
Total Permanent Staff	1,5	9	2	o	10	o	0,5	1	1	25
R. van Kanten		2								2
P. Siles		2	2	2						6
J. Angrand			10							10
H. Avila				10						10
G. Avila Vargas					0,5					0,5
Marta Gutierrez				2						2
Rodolfo Munguia					2					2
Field assistants		3		2	3,9					8,9
Total Hired Staff	o	7	12	16	6,4	o	o	0	0	41,4
Total CATIE	1,5	16	14	16	16,4	o	0,5	1	1	66,4

INFORME SOBRE LA EJECUCION

DEL PROYECTO CASCA

POR PARTE DE CICAFE

Carlos Fonseca (Cicafe-IICA-Promecafé)

INTRODUCCION

En el presente informe se resume la participaci6n de CICAFE en el proyecto desde la instalaci6n de los trabajos de campo al inicio deI presente ano hasta finales deI mes de octubre.
Ademas de la instalaci6n de las parcelas de campo de ha brindado apoya logîstico y se han llevado a cabo labores de îndole administrativa relacionadas con el proyecto.
A continuaci6n se detallarán la ejecuci6n de los diferentes paquetes de trabajo tanto en las áreas biofisicas coma socioecon6micas.

ASPECTOS BIOFISICOS

Se iniciaron investigaciones relativas a los paquetes de trabajo 2 y 4 (wp2 wp4)
En 10 que se refiere al paquete 2 (wp2) en donde se estudia y compara la dinarnica de agua biomasa y nitr6geno en sistemas de producci6n al sol y con sombra de <u>Inga</u> <u>sp.</u> en dos parcelas experimentales
Se han realizado las cuantificaciones de producci6n crecimiento asî coma los analisis de laboratorio respectivos con una ejecuci6n deI 100%, según 10 programado.

Con relaci6n al paquete 4 (WP 4) en donde se estudia la influencia deI nivel de fertilizaci6n sobre la producci6n de biomasa de café y las pérdidas de nitr6geno en un sistema de producci6n a pleno sol.
Se realizaron al igual que el experimento anterior todas las cuantificaciones programadas con una ejecuci6n deI 100%

En 10 que respecta al paquete de trabajo 6 (wp 6) se realiz6 la busqueda de informaci6n respecto a la especie <u>Erythina</u> sp existente en el paîs.

ASPECTOS SOCIOECONOMICOS

En cuanto al paquete 1, se apoyaron los trabajos que ejecutaron los estudiantes franceses, se les brind6 apoyo logistico, ubicaci6n dentro de la regional y se contactaron con lideres de la caficultura de la zona.

En 10 que se refiere al paquete 8, se brind6 inforrnaci6n de la caficultura de Costa Rica respecto a estadisticas cafetaleras de comercializaci6n modelos de costos y pago de café a productores en los ultimos allos.

En cuanto a la participaci6n de CrCAFE en el proyecto se han involucrado en el presente periodo cinco funcionarios en las diferentes actividades tanto técnicas coma administrativas con una participaci6n deI 10% deI tiempo destinado a CASCA.

UNIVERSIDAD NACIONAL AGRARIA

INFORME ANUAL DEL PROYECTO UNAICASCA EN NICARAGUA

AÑO 2001 - 2002

Elaborado por: Glenda Bonilla M.Sc.

OCTUBRE 2002

1. INTRODUCCION

El Proyecto "Sistemas Agroforestales de Café en Centroamérica" conocido como CASCA, con financiamiento de la Uni6n Europea, inici6 el 1 de noviembre de 2001 y tiene una duraci6n de cuatro anos. El objetivo dei presente informe es presentar las actividades que ha realizado la Universidad Nacional Agraria como socio dei Proyecto, durante el primer año de ejecuci6n (noviembre 2001 - octubre 2002).

2. PRINCIPALES INVESTIGADORES DE LA UNA

Los Docentes-investigadores involucrados, como parte dei equipo de la UNA, en el proyecto CASCA son la M.Sc. Glenda Bonilla , el Dr. Victor Aguilar, el Lie. Crist6bal Medina, el Dr. Emilio Pérez, el M.Sc. Leonardo Garcia yel Ing. Claudio Calero. Segun las especialidades de eada une de los integrantes dei equipo, se design6 las responsabilidades en el proyecto y los paquetes de trabajo en los euales participara de lleno.

3. ACTIVIDADES REALIZADAS.

3.1. PRIMER SEMESTRE (NOVIEMBRE 2001 - ABRIL 2002)

Las principales actividades desarrolladas durante los 6 primeros meses dei proyecto han sido:

*3.1.1 **Reuniones de trabajo en la UNA.***

Durante el mes de Noviembre de 2001 se reuni6 a todo el equipo para dar a conocer el proyecto y las responsabilidades de cada uno. Se estableci6 realizar una reuni6n mensual para informar sobre los avances dei proyecto.

*3.1.2. **Taller de planificaci6n de Actividades dei Proyecto.***

Del 26 al 30 de Noviembre de 2001 se desarroll6 el primer taller de trabajo con todos los socios de los cinco paises para planificar las actividades a desarrollar. Asistieron a este evento, por parte de la UNA, la M.Sc. Bonilla y el Dr. Aguilar, quienes presentaron las investigaciones hechas y las que actualmente se están llevando a eabo sobre el cultivo de café y que pudiesen tener incidencia eon el proyecto. También presentaron el quehacer de la Universidad Nacional Agraria, su misi6n, visi6n e importancia en el campo dei desarrollo agropecuario y forestal en Nicaragua. Los resultados de este evento son presentados en la memoria o reporte que se elabor6 para tal efeeto.

3.1.3. ***Reunion del equipo de especialistas para los estudios biofisicos en Nicaragua.***

Del 10 al 12 de Abril de 2002 se dia la primera reuni6n de planificaci6n en Nicaragua, en el recinto de la UNA. Asistieron a esta reuni6n el Dr. Philippe Vaast, como Coordinador General dei Proyecto, el Dr. Jean Michael Harmand, coordinador dei paquete de trabajo 4, ambos dei CIRAD; el Dr. Charles Stayer y el Dr. Jeremy Haggar, ambos dei Proyecto CATIE-MIP/NORAD en Nicaragua; y por parte de la UNA asistieron los seis Docentes-investigadores anteriormente mencionados como miembros dei equipo.

En esta reuni6n se hizo una reseJïa sobre los trabajos de investigaci6n en los que está trabajando la UNA. Se visit6 la zona dei Pacifico de Nicaragua, especificamente el Jardin Botanico 0 Centro de Experimentaci6n de Café y la Finca Santa Rosa en donde por las caracteristicas de la especie empleada como sombra *Gliricidia sepium* y que fue la especie seleccionada para realizar estudios en cafetales con esta especie y también por la disposici6n e interés de los duenos de la finca en apoyar los estudios que realizara el proyecto, fue seleccionada para realizar los estudios biofisicos. Se definieron los objetivos y variables a medir:

Obtener un modela hidrico para obtener un balance de distribuci6n de drenaje en el suelo, a partir dei cual se realizaran los estudios de fisiologia (flujo de savia, transpiraci6n dei árbol y dei cultivo y humedad dei suelo) y nutrici6n dei cultivo. También se obtendran modelos de mineralizaci6n de la materia organica y de nitr6geno disponible, y obtener la interacci6n arbol-café. Formar una base de datos sobre temperatura, precipitaci6n, humedad edáfica, iluminaci6n, evapotranspiraci6n, humedad relativa. Medir variables de la planta de cafeto como la biomasa, tante en la planta como en el cafeto, incremento de la parte aérea de la raiz, producci6n de hojarasca con el prop6sito de establecer un balance de entradas y salidas dei sistema. Se acord6 elaborar los protocolos de investigaci6n de la parte biofisica.

3.1.4. ***Reunion del equipo de especialistas para los estudios socioeconomicos en Nicaragua.***

Del 22 al 24 de Abril de 2002 se reunieron en Managua los coordinadores de los paquetes de trabajo 1, 7 Y 8, los doctores Eduardo Somarriba, Philippe Bonnal y Gerry Lawson; asimismo participaron en la reuni6n el Dr. E. Pérez, la M.Sc. G. Bonilla y los estudiantes de la UNA, Arien L6pez, Luis Orozco y Rodolfo Castillo.

Durante estos tres dias de trabajo se hizo un analisis sobre los criterios para definir la zona de incidencia para levantar la informaci6n socioecon6mica. Se visit6 a la Fundaci6n FUNJIDES en el Departamento de Jinotega, una de las zonas más importantes de la caficultura en Nicaragua y ellos nos orientaron sobre las rutas 16gicas para realizar el recorrido de reconocimiento de la zona. Se visit6 el Ministerio de Agricultura y Forestal (MAG-FOR), alli nos atendieron los ingenieros Luis Valerio y Benjamin Herrera, especialistas en Sistemas de Informaci6n Geográfica y en Suelos respectivamente. Una primera definici6n sobre la selecci6n de las muestras es a partir de mapas con los cuales se generaran cuadriculas de 1 Km2 , también se hará uso de mapas de elevaciones, precipitaci6n, tipo de suelo, uso potencial dei suelo y fotografias aéreas si las hubiese. Se cuenta con una base de datos sobre variables socioecon6micas de la zona cafetalera dei Pacifico de Nicaragua.

3.2. SEGUNDO SEMESTRE (MAYO - OCTUBRE 2002)

Durante el segundo semestre de actividades dei proyecto se enfoc6 a realizar los trabajos de campo. Para cumplir con los objetivos planificados en las dos reuniones de planificaci6n que se tuvieron en abril de 2002 en la Universidad Nacional Agraria, tante para los paquetes de trabajos que se resumen en Aspectos **Biofisicos** y Aspectos Socioeconomicos, se definieron las áreas de trabajo: en la Finca San Francisco se establecieron las parcelas experimentales una vez que fueron definidos los protocolos de investigaci6n y en el Departamento de Matagalpa se llev6 a cabo la recopilaci6n de informaci6n por media de una encuesta preliminar.

Toda la infarmaci6n tante para los aspectos biofisicos como para los aspectos socioecon6micos, está recolectada por los seis docentes investigadores como par los seis estudiantes de la Universidad Nacional Agraria. Durante este primer año de actividades dei proyecto se contabilizaron 50 dias de viajes al campo realizados par docentes y 172 dias de viajes al campo par parte de los estudiantes.

3.2.1. Aspectos biofisicos : Luz, Agua (WP2), Fisi%gia de/ café (WP3), Nitr6geno (WP4), Carbono (WP5) y Mode/aje (WP6).

En el marco de trabajo de Aspectos Biofisicos dei proyecto se estableci6 el estudio de sistemas agroforestales *café-Gliricidia sepium* en la Regi6n dei Pacifico de Nicaragua y las principales actividades desarrolladas fueron las siguientes:

1. En el mes de junio quedaron establecidas las negociaciones de trabajo con el Ing. Guillermo Quin6nez, Administrador de las tres fincas de la Empresa Inversiones S.A.

2. Se establecieron las parcelas experimentales en el campo y están ubicadas en una de las tres fincas de la empresa, especificamente en la Finca San Francisco. El área experimental tiene las siguientes caracteristicas:

CULTIVa:	*Coffea arabica* L.
VARIEDAD:	T-86670 Costa Rica 95
SOMBRA:	*Gliricidia sepium* (Jacq.) Kulth
EDAD:	5 años
LUGAR:	Finca San Francisco, San Marcos, Carazo
ALTITUD:	450 msnm

Trabajos dirigidos por PROMECAFE

T-5269	Guatemala
IHCAFE 90 0 T-5175	Honduras
CATRENIC	Nicaragua
T8667 0 Costa Rica 95	Costa Rica

3. Las tres parcelas experimentales establecidas en el campo son:

A. Café con sombra de Madero Negro con fertilizante quimico
B. Café sin sombra (a pleno sol) con fertilizante quimico
C. Café con sombra de madero negro sin fertilizacian quimica

40 metros	40 metros	40 metros
Café mas Madero con fertilizante 24 surcos	Café sin sombra con fertilizante 24 surcos	Café mas Madero sin fertilizante 24 surcos

Area 40 m X 48 m $=$1920 m^2 5760 m^2

Poblacian: 5000 plantas/ha
Distanciamiento de plantacian: 1 metro entre plantas 2 metros entre surcos

4. se realiza el inventario de los cafetos en cada una de las tres parcelas. Se *toma* la altura y el diametro de 120 plantas por parcela y se *toma* la media general equivalente a 115 cm de altura y 3 mm de diametro. El diametro se *toma* a 10 cm sobre la superficie dei suelo.

5. Se marcaron 8 plantas de café por parcela cercanas a la media de altura y diametro para un total de 24 plantas.

6. Se midieron las siguientes variables:

Variables de crecimiento, desarrollo y *producci6n en las plantas de café:*

- Altura de plantas (cm)
  Diametro dei tallo (mm)
  Proyeccian de copa (m2
  Numero de nudos en el tallo principal
  Numero de ramas primarias
  Numero de ramas productivas
  Numero de ramas agotadas

Numero de ramas secundarias totales
Numero de ramas secundarias productivas
Numero de ramas terciarias totales
Numero de ramas terciarias productivas

Variables en ramas 7, 11, 15, 19, 23 Y 27:

Largo dei tejido viejo y nuevo de ramas primarias
Numero de nudos en tejido viejo y nuevo de ramas primarias, secundarias y terciarias
Nudos productivos en ramas primarias y secundarias
Numero de hojas en tejido viejo y nuevo de ramas primarias, secundarias y terciarias
Largo y ancho de una hoja de cada nudo de ramas primarias, secundarias y terciarias
Numero de frutos por nudo en ramas primarias, secundarias y terciarias

Variables tomadas para incremento de biomasa seca:

Peso seco de los frutos
Peso seco de las hojas
Peso seco de las ramas
Peso seco dei tallo
Peso seco de la raÎz principal
Peso seco de las raÎces menores de 2 mm
Peso seco de las raÎces iguales o mayores a 2 mm
Longitud de la raÎz principal

Devoluci6n de biomasa seca *por poda de Madero negro (se midi6 en* 5 *arboles por parcela:*

Peso seco de las hojas
Peso seco de las ramas y tallos

Medici6n de altura y *diametro* a *la altura del pecha de todos los arboles de Gliricidia sepium.*

Cosecha de café seco y *maduro (graniteo) por parcela.*

7. Otras actividades:
   Control de malezas mecanico y quimico con paraquat
   Fertilizaci6n con triple 15 en dos parcelas
   Elevaci6n y descentralizaci6n de la sombra

3.2.2. Aspectos Socioeconomicos: Caracterizacion (WP1), Economia (WP7), Regionalizacion (WP8)

En el marco de trabajo de Aspectos Socioecon6micos dei proyecto se realiz6 la aplicaci6n de una encuesta preliminar en el Departamento de Matagalpa para recolectar toda la informaci6n necesaria. Se seleccion6 el Departamento de Matagalpa y no Jinotega, debido a las dificultades de acceso que presenta la zona de Jinotega.

En el mes de julio dei 2002, los cuatro estudiantes nicaragüenses que están participando en esta investigaci6n, viajaron a Turrialba, Costa Rica para revisar literatura y discutir las metodologias de investigaci6n con el Dr. Eduardo Somarriba.

El muestreo de la zona cafetalera en estudio se está haciendo a dos niveles, comenzando con la encuesta preliminar que es la que se aplic6 durante el segundo semestre dei primer ano de actividades dei proyecto. El objetivo de esta encuesta preliminar fue el de identificar las grandes tipologias agroforestales y de finca en diferentes sub-zonas agroecol6gicas de la zona de estudio.

En el mes de Agosto se visit6 a la Uni6n de Cafetaleros de Nicaragua (UNICAFE) en Matagalpa, y los Ingenieros José Avener, Melba Morales y César Centeno brindaron lista de productores de las diferentes comunidades de los municipios de San Ram6n y Matagalpa yel Ingeniero Aldo Marques quien brind6 la informaci6n de las comunidades dei municipio Tuma-La Dalia.

Asimismo se visit6 la Asociaci6n de Cafetaleros de Matagalpa (ASOCAFEMAT) y la persona que brind6 informaci6n secundaria, necesaria para realizar el estudio en el Departamento fue el Ing. Celso Bonilla.

Posteriormente, en ese mismo mes se realiz6 la gira exploratoria a comunidades en donde posteriormente se aplicaron las encuestas. Esta gira fue apoyada por la Ing. Blanca Lacayo dei Programa Socio Ambiental y Desarrollo Forestal (POSAF - MARENA).

3.3 PLANIFICACION DE ACTIVIDADES PARA EL AÑO 2003.

3.3.1. Aspectos Biofisicos (WP2, 3,4, 5 Y 6):

Estudios de sistemas agroforestales con café y *madero negro (Gliricidia sepium) en la Region del Pacifico de Nicaragua*

Las actividades planificadas a desarrollar desde enero a diciembre dei 2003 en la parcela experimental ubicada en la Regi6n dei Pacifico de Nicaragua son las siguientes:

1. Preparaci6n y establecimiento de canastas para recolecci6n mensual de hojas y ramas de café y Madero Negro *(Gliricidia sepium).* Realizar analisis quimico por muestra, de enero a diciembre 2003.

2. Medici6n de altura y diametro de todas las plantas de café y marcado en la rama numero 7 de 48 plantas de café por parcela para datos de crecimiento y biomasa en el 2003 y 2004 según dato promedio general para un total de 144 plantas. Abril dei 2003.

3. Medici6n de las siguientes variables de crecimiento, desarrollo y producci6n en las plantas de café, en mayo, agosto y diciembre dei 2003:

   - Altura de plantas (cm)
   - Diametro dei tallo (mm)
   - Proyecci6n de copa (m2
   - Numero de nudos en el tallo principal
   - Numero de ramas primarias
   - Numero de ramas productivas
   - Numero de ramas agotadas
   - Numero de ramas secundarias totales
   - Numero de ramas secundarias productivas
   - Numero de ramas terciarias totales
   - Numero de ramas terciarias productivas

Variables en ramas 7, 11, 15, 19, 23 Y 27 a tomar en mayo, agosto y diciembre dei 2003:

- Largo dei tejido viejo y nuevo de ramas primarias
- Numero de nudos en tejido viejo y nuevo de ramas primarias, secundarias y terciarias
- Nudos productivos en ramas primarias y secundarias
- Numero de hojas en tejido viejo y nuevo de ramas primarias, secundarias y terciarias
- Largo y ancho de una hoja de cada nudo de ramas primarias, secundarias y terciarias
- Numero de frutos por nudo en ramas primarias, secundarias y terciarias

4. Variables a tomar para incremento de biomasa seca en mayo, agosto y diciembre dei 2003:

   - Peso seco de los frutos
   - Peso seco de las hojas
   - Peso seco de las ramas

- Peso seco dei tallo
- Peso seco de la raiz principal
- Peso seco de las raices menores de 2 mm
- Peso seco de las raices iguales o mayores a 2 mm
- Longitud de la raiz principal
- Analisis quimico (N) 3 muestras por muestreo

5. Devoluci6n de biomasa seca por poda de Madero negro por parcela en septiembre 2003.

   - Peso seco de las hojas
   - Peso seco de las ramas y tallos
   - Realizar analisis quimico (N)

6. Medici6n de altura y diametro a la altura dei pecha de todos los arboles de *Gliricidia sepium* por parcela en abril 2003.

7. Cosecha de café seco y maduro (graniteo) por parcela, cosecha de café maduro (cosecha plena), cosecha de café maduro y verde (repela). Hacer analisis quimico y calidad de tasa por cosecha por parcela, en noviembre, diciembre 2003 y enero 2004.

8. Otras actividades durante el año 2003:
   Control de malezas mecanico y quimico
   Fertilizaci6n Uunio, agosto y noviembre)
   Elevaci6n y descentralizaci6n de la sombra (septiembre)

3.3.2. Aspectos Socioecon6micos (WP 1, 7 Y 8).

Recopilaci6n de informaci6n en el Departamento de Mataga/pa, procesamiento, ami/isis y *pub/icaci6n de resu/tados.*

Se ha planificado que a partir dei mes de noviembre dei 2002 a febrero dei 2003, con el marco de muestreo y extrapolaci6n, se estudien las fincas seleccionadas y a un mayor nivel de profundidad para desarrollar las tipologias de finca y obtener la informaci6n cuantitativa sobre manejo de cafetales y disenos de finca e identificar escenarios de interés para modelaci6n socioecon6mica, etc.

Para levantar la informaci6n de campo para los estudios a profundidad, se utilizara un formulario que ha sido empleado por estudiantes de maestria dei CATIE para realizar estudios sobre tipologias cafetaleras en Costa Rica, Nicaragua y El Salvador, pero ha sido ajustado a los objetivos de investigaci6n dei proyecto CASCA.

Se ha planificado que al finalizar el levantamiento de la informaci6n y su respectivo analisis, se procedera a publicar un articulo, dos tesis de grade y presentaciones técnicas con grupos de interés, para dar a conocer los resultados obtenidos.

3.3.3. Otras Actividades

Entre los socios dei Proyecto CASCA acordamos también recolectar informaciones de base de datos de suelos, temperatura, superficie de café, sombra, etc. Asimismo sobre sellos de café, sobre mercadeo de la madera y pautas que conlleven a evaluar el servicio ambiental dei Sistema agroforestal con café referido a secuestro de carbono.

La reuni6n anual dei Proyecto CASCA para el ano 2003, se concret6 para el periodo dei 10 al 14 de noviembre.

Actual Partitioning of months IWP/PARTNERIfor the FIRST YEAR

Socio	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	WP9	Yr1
UNA										
Glenda Bonilla	2						1	0,5		3,5
Victor Aguilar B			1,5		1,5					3
Jasmina Garibo									1	1
Emilio Pérez	1						0,5	0,5		2
Cristobal Medina B.			0,5		0,5					1
Leonardo Garcia			1,5		0,5					2
Claudio Calera			0,25		0,5					0,75
Victor Calderon			0,25		0,25					0,5
Totai Permanent staff	3	0	4	0	3,25	0	1,5	1	1	13,75
Arien L6pez	1						1			2
Luis Orozco	1						1			2
Rodolfo Castillo	1						1			2
Cesar Campos	1						1			2
Diana Diaz Valle			0,3		0,3					0,6
Justa E. Castro			0,5		0,5					1
Elmer martinez			0,125		0,125					0,25
Hamilton Flores			0,125		0,125					0,25
Drivers	0,25		0,25		0,25		0,25	0,25		1,25
Field technicians			0,25		0,25					0,5
Total Hired Staff	4,25	0	1,55	0	1,55	0	4,25	0,25	0	11,85
Total UNA	7,25	0	5,55	0	4,8	0	5,75	1,25	1	25,6

CASCA

First ADDual Report WORK PACKAGE 1

INFORME 2002

WPl - CASCA - Central America coffee agroforestry knowledge

Eduardo Somarriba

CATIE, Leader of WP 1

12 diciembre 2002

Avances

- Se reviso y actualizo la base de datos de fincas cafetaleras de Costa Rica (Turrialba), Nicaragua (Carazo y Esteli) y El Salvador (Santa Ana-Ahuachapân). Se adjunta copia de la base de datos (Encuesta de cafe.xls) y deI documento que describe la metodologia (Metodo105 .doc).
- Se analizo parcialmente la base de datos y los resultados se incluyeron coma parte de un capitulo deI libro sobre la conservacion de la biodiversidad en diferentes sistemas agroforestales (Somarriba et al 2003). Los resultados se incorporaron en el capitulo sobre cafetales. El articulo discute camo interpretar las diferencias de la composicion botânica, la diversidad productiva y la estructura deI dosel de sombra difiere entre fincas, regiones cafetaleras y paises y camo esas diferencias afectan la conservacion de la biodiversidad.
- Se re-estructuro la encuesta base para incluir una evaluacion completa de todo el sistema de produccion (la finca) y no solo enfatizar el anâlisis de los cafetales. Este nuevo formulario (metodo105.doc; adjunto) se aplico en el estudio de los cafetales de Naranjo – San Ramon, Costa Rica y se aplicarâ (2003) en los de Tuma - La Dalia, Matagalpa, Nicaragua.
- En 2002, se estudiaron los cafetales de Naranjo - San Ramon, pero no se han incorporado los datos a la nueva base de datos. Los cafetales de Naranjo-Palmares utilizan tres especies de guaba coma sombra y dos especies de poro (E. poeppigiana y E. fusca), en algunas sub-zonas, son comunes los asocios con Dracaena (cana india) coma cultivo para la exportacion, es una zona con muchos caminos asfaltados, excelente acceso y con numerosas oportunidades de empleo no rural, especialmente, en mueblerias. La zona incluye sub-zonas altas, ventosas y nubosas con poca o ninguna sombra y zonas con fuerte déficit hidrico en unos seis meses deI

ano. Se observaron fincas con eucaliptos deglupta coma sombra; establecidas con incentivos forestales y no tienen buena recepcion por la baja calidad de la madera y por los efectos negativos severos que el exceso de poblacion arborea (requerido para obtener los incentivos forestales) provoca sobre el rendimiento deI café. Similares experiencias han tenido los productores al asociar citricos en el cafetal.

- Se inicio el estudio de los cafetales de Matagalpa, Nicaragua mediante las tesis de cuatro estudiantes de ultimo ano deI Departamento Forestal de la UNA, Managua, Nicaragua. Los estudiantes trabajan en parejas, en dos sub-zonas de la region cafetalera Tuma - La Dalia, la principal zona cafetalera de Matagalpa, y por ende, deI pais. Se completaron las encuestas de reconocimiento en 51 fincas deI territorio (Encuesta preliminar2.doc). Los estudios detallados de las fincas que serán analizadas con el nuevo formulario (Metodo105.doc) se iniciaron a principios de diciembre 2002 y se completaran en junio 2003.
- Se adopto un cambio de enfoque en la seleccion de zonas y tipo de estudios socioeconomicos y tipologicos de cafetales para asegurar compatibilidad entre los resultados biofisicos (que trabaja con una seleccion definida de especies de sombra - Erythrina poeppigiana, Gliricidia sepium, Inga spp., Cordia alliodora, Terminalia ivorensis, Eucaliptus deglupta, T. amazonica y Grevilea robusta- y una lista corta de recursos: radiacion, agua y nitrogeno). Los estudios tipologicos y socioeconomicos deI 2001 pretendieron estudiar el más amplio rango posible de condiciones socioeconomicas y biofisicas que determinan el diseno de las fincas cafetaleras y de sus cafetales. La base de datos disponible a inicios deI 2002 ofrecia datos sobre cafetales de bajura y clima estacionalmente seco (Santa Ana, El Salvador y Carazo, Nicaragua), cafetales de zonas altas y clima estacional (Ahuachapan, El Salvador), zonas altas y secas (Esteli, Nicaragua), zonas bajas y lluviosas (Turrialba, Costa Rica). Los nuevos estudios deI 2002 en Costa Rica ofrecen informacion sobre zonas medias y altas y con clima estacionalmente seco (Naranjo - San Ramon, Costa Rica) y los estudios en Tuma - La Dalia darán informacion sobre zonas medias y altas humedas (Matagalpa, Nicaragua). Estas zonas estudiadas proporcionan informacion sobre diferentes especies de sombra: 1) E. poeppigiana, C. alliodora y musaceas en Turrialba; 2) E. poeppigiana, E. fusca, Inga spp. y E. deglupta en Naranjo-San Ramon; 3) Gliricidia sepium en Carazo, 4) Inga spp. en El Salvador (ambas sub-zonas) y Matagalpa. Los estudios deI 2003 se dirigen a la zona de Pérez Zeledon, Costa Rica, zona humeda en todo el rango altitudinal (500 - 1500 m y hacia el rescate de los estudios en

Guatemala, en la zona alta y humeda de Antigua donde se cultiva café bajo sombra de Grevilea robusta. Los cafetales de Perez Zeledon tienen poro y guaba coma sombra, las zonas son l1uviosas (3000 – 4000 mm), entre 700-900 m altitud la mayoria, notorio el asocio de bananos y platanos en los cafetales, citricos, pejival1es, mamones chinos y otros frutales comerciales son comunes en intersticios de la finca. Los estudios socioeconomicos a nivel de finca cafetalera y cafetal se complementaran con estudios deI manejo agroforestal deI dosel de sombra de los cafetales.

Publicaciones, formularios, metodologias, etc.

Eduardo Somarriba, Celia A. Harvey, Mario Samper, Francois Anthony, Jorge Gonzalez, Charles Stayer and Robert Rice (2003) Conservation ofbiodiversity in neotropical coffee *(CofJea arabica)* plantations. In. Agroforestry and Biodiversity Conservation in Tropical Landscapes, Eds. G. Schroth, G. Fonseca, c.A. Harvey, C. Gascon, H. Vasconcelos and A.M.N. Izac. Island Press, Washington, USA. **In** press.

- Guezennec S et Nougadere A (2003) Diagnostico técnico – economico de una pequefia region cafetalera de altura (Provincia de Alajuela, Costa Rica). CNEARC, Francia. En prensa.
- Metodologia actualizada para estudio socioeconomico profundo de fincas cafetaleras (Metodo105.doc); 2) Metodologia para el estudio exploratorio de cafetales (Encuesta preliminar2.doc); 3) Bases de datos de fincas cafetaleras en Turrialba (Costa Rica), Carazo y Esteli (Nicaragua) y Santa Ana - Ahuachapan (El Salvador) (Encuestas de café.xls).

Estudiantes 2002

- Guezennec, Sten, CNEARC, Ingenieria Agricola, Francia
- Nougadere, Alexandre, CNEARC, Ingenieria Agricola, Francia
- Orozco, Luis, UNA, Ingenieria Forestal, Nicaragua
- Lopez, ArIen, UNA, Ingenieria Forestal, Nicaragua
- Campos, César, UNA, Ingenieria Forestal, Nicaragua
- Rodolfo Castillo, UNA, Ingenieria Forestal, Nicaragua

Acciones en 2003

- Actualizar bases de datos, incluyendo la incorporacion de los datos de fincas de Naranjo-San Ramon, Costa Rica y los datos de fincas deI Tuma - La Dalia, Nicaragua.

- Completar los estudios de las fincas de Tuma – La Dalia, estudiar las fincas cafetaleras de Pérez Zeledon, Costa Rica y preparar los estudios en Guatemala (2004).
- Divulgacion de los resultados obtenidos a la fecha. Se elaborarân articulos técnico-divulgativos basados en las tesis de los estudiantes franceses, nicaragüenses y costarricenses. En cooperacion con UNA e rCAFE se harân presentaciones cientifico-técnicas a los equipos locales de estas instituciones y a otros profesionales dei sector cafetalero que trabajan en las regiones de estudio dei Proyecto CASCA.
- En cooperacion con WP#7 elaborar modelo tipologico /socioeconomico de las fincas cafetaleras que modelaremos. En este modelo es necesario equilibrar las funciones economicas y las extemalidades que maximisan los beneficios de diferentes actores

CASCA

First Annual Report WORK PACKAGE 2

LIGHT and WATER PARTITIONING at PLOT SCALE

Dr. Jean Dauzat (CIRAD), leader ofWP2

Dr. Gustavo Anzola (CATIE), Dr. Philippe Vaast (CIRAD), Rudi van Kanten (CATIE).

The four tasks of the WP2 are:

- To quantify shading by u'ees in coffee AF systems
- To fit a 3-D light model and perform shading simulation experiments at plot scale
- To quantify and model the water uptake of coffee trees and associated shade/timber trees
- To adapt and parameterise a water balance model for a 'two source' canopy

Light measurement and modelling in the canopy of associated tree

Dr. Jean Dauzat (CIRAD), leader ofWP2

Dr. Gustavo Anzola (CATIE)

1. Methodology

The following approach has been pursued to quantify and model the light interception within coffee agroforestry systems,:

1. In situ description of the crown of individual trees within agroforesu'y systems;
2. Assessment of light interception by these trees using a photographie method;
3. Realisation of hellÙspherical photographs in order to control the actuallight interception at the plot scale and validate the light model;
4. Simulation of light interception by 3D representations of tree crowns and parameterisation of their light porosity;
5. Calibration and validation of the light interception by 3D plant models;
6. Simulation experiments in order to fit sellÙ-empiricallaws capable to assess the light interception in various agroforestry systems composed of different species, at different ages and in different seasons.

1.1. <u>In situ description of the crown of individual trees</u>

The main <u>objective</u> is to get simple representation of single trees (with a volullÙc representation of their crown) which will be used to simulate the light interception within a stand.

A simple in situ <u>protocol</u>, easily transferable to non-specialist workers, has been used. It requires a measuring tape, a compass and a (digital) camera. Measurements for selected trees consist in:

- Measuring the maximal extent of crown projection in height direction, usually toward north, east, south and west, plus the intermediate directions. This is made by positioning sticks on the ground below the crown (possibly with the help of a plumb-line) and measuring their distance to the trunk;
- Measuring the trunk diameter at breast height (DBH);
- Taking silhouette photographs of the tree from two perpendicular directions: north or south and east or west according to the local environment of trees, keeping in mind that the neighbouring trees will have later to be c1eared out of the image in order to quantify the silhouette area of the selected tree. If photographs are not taken from cardinal points, the azimuth of the points of view must be noted. The distance to tree when

taking the photographs must be at least equal to the tree height and it must be noted. Additional recommendations are given below in annex "Treatrnent of digital images".

- Due to the particular crown shape of *Terminalia ivorensis*, the tree description consisted in the measurement of the height and radius of foliage disks.

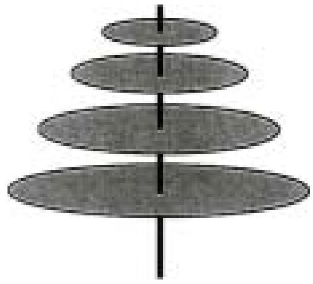

Figure 1: schematic representation of *Terminalia ivorensis*

1.2. In situ assessment of light interception by individual trees using a photographie method

The objective is to assess the light interception by individual trees in given directions.

The principle is to take snapshots of individual trees from sorne directions to quantify the intercepting area of foliage for light in corresponding directions. Only sorne directions are sampled in order to associate a light porosity to the 3D crown representations modelled as described above. The image treatrnent consists in clearing the surrounding of the selected tree and then in counting the number of green pixels corresponding to the foliage of the tree.

The protocol for in situ measurements has been designed in order to be rapid and simple. It requires a measuring tape, a compass and a (digital) camera and is combined with the measurements described above. Snapshots are taken as previously from two directions (north or south and east or west when possible) from given distances to the tree base. The regular distances used at this time were every five meters from zero (at the base of the tree) up to a distance equal to the tree height (the images taken from the maximal distance being used for the description of the crown silhouette).

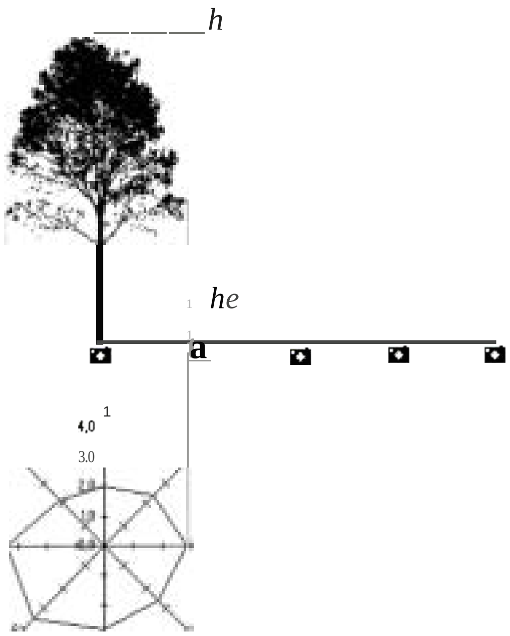

figure 2:

Measurement of the crown projection in eight directions;

Silhouette photographs of individual trees are taken every Sm from 0 up to a distance at least equal to the tree height along two perpendicular transects.

The quantification of the tree intercepting area for light is made on the digital images after clearing the surrounding ofthe selected tree with a commercial software. In some case the background and/or the foreground must be removed on a part of the image of the tree silhouette. This operation is cumbersome and rime consuming. Therefore it is recommended to: 1. avoid the trees with such problems as far as possible; II. Clear the images only when the operation doesn't risk to bias the estimation ofthe area ofintercepting foliage; otherwise, discard the images: it is preferable to quantify the crown porosity with few images than to introduce a possible bias in some images.

Figure 3:

Silhouettes of *Cordia alliodora*

Figure 4: left: Examples of *Cordia alliodora* silhouettes after clearing the images and and their transformation into binary images.

Right: crown model for simulations.

1.3. Realisation ofhemispherical photographs

The objective ofhemispherical photographs is to quantify the light transmission within a plot. These data will be used fust to control the simulation oflight interception on volumic plant models (§ 1 and 2) and, in the future, to re-parameterise the crown porosity for light oftrees in new stands.

The protocol used for the fust measurements consisted in taking photographs every 2 meters along a square pattern. Such a protocol was designed, despite it is rather heavy, in order 1: to get the maximum of points of control for validating the light model and II: to let the possibility of selecting the more interesting points for designing a lighter protocol.

The interpretation ofhemispherical photographs has been made with the commercial software "Hemiview[1]" and the freeware "GLA[2]". The main features of either software are:

- The classification ofimage pixels into sky and vegetation;
- The calculation of gap fractions (i.e. the percentage of visible sky) within sectors defined by splitting the whole sky hemisphere into concentric crowns and azimuth sectors;
- The assessment of the leafarea index ofthe plot;
- The assessment of the transmitted light at the point where the photographs have been taken.

It appears that GLA is more powerful for classifying the sky and vegetation pixels by offering the possibilities: 1. to apply classical corrections to the images (acting on brightness, contrast, sharpness...) and II. to choose a colour plane (Red, Green or Blue). Nevertheless, in sorne cases, it was necessary to perform the classification of pixels with another software (Paint Shop Pro: see technical annexes).

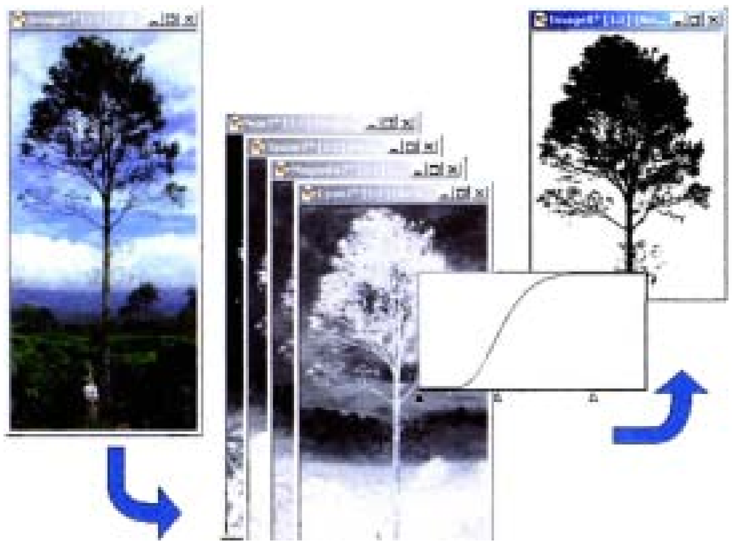

Figure 5:
Classification of tree and backgroud pixels by applying a threshold on the luminance histogram

Despite the assessment of the LAI of the tree strata in coffee agroforestry systems is not a primary objective of the CASCA project, sorne attention was paid to the quality of assessment performed by GLA and Hemiview. It appeared that 1: the estimations given by the two softwares differ and II: these estimations may strongly underestimate the actual LAI. A more comprehensive study is on the way and willlead to a technical note.

1.4. Simulation oflight interception by 3D representations oftree crowns

The existing program for simulating the light interception (MIR) calculate projection images of 3D plant models containing information similar to the information obtained by in situ photographs. Until recently, the program could only calculate the projection of "surfacic" representations of trees i.e. with individualleaves represented by polygons. Thus, for simulating the light interception by "volumic" crown shapes, it was necessary to simulate individual leaves within the volume of the crown shape using the "topiary" program. Two extensions of the programs have been made:

1. The output of a polygonal representation of selected shapes by the topiary program;

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1 Hemiview Canopy Analysis Software, version 2.1, commercialised by Delta-T Devices Ud (http://www.delta-t.co.uk/)

2 Gap Light Analyser, version 2.0. (http://www.rem.sfu.calforestry/index.htm and http://www.ecostudies.orgl)

2. The adaptation of MIR to calculate the optical pathway of light within the crown shape.

ûwîng to these adaptations, it will be possible to simulate in a near future the light interception with a much shorter computation time and less requirement of computer memory. Systematic simulations of the trees already described will be performed during the fust semester of 2003.

Possible representation of crown shapes are presently spheres and ellipsoids, cylinders, cones and parallelograms. More complicated shapes remain possible by truncation of these shapes (fig. 6, right) and concatenation of several shapes. One of the simplest crown representation to be tested (at least for *Cordia alliodora)* will he the concatenation of an hemisphere with a truncated cone as represented in figure 4, right. In the particular case of *Terminalia ivorensis*, the crown will be represented as a set of horizontal dîsks.

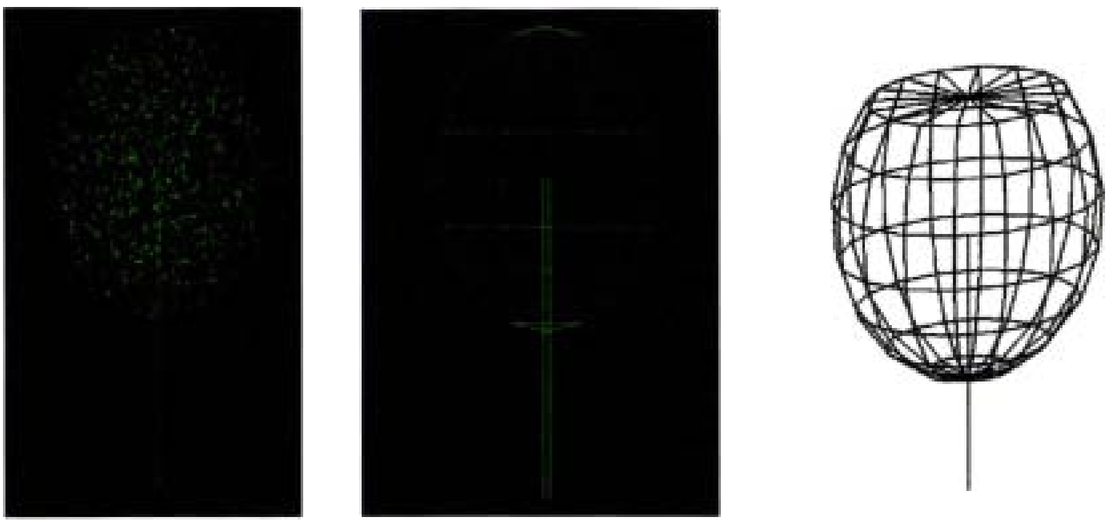


figure 6: left: "surfacic" representation of foliage within an ellipsoidal crown shape.
Middle: "volumetric" representation of the ellipsoidal crown shape.
Right: perspective view of a truncated ellipsoidal tree crown.

1.5. Fitting of semi-empirical laws predicting the light transmission under shade timber trees

The fust question to address is the association of a light porosity model to the crown shape that will be able to reproduce the light interception as estimated by field photographs in sampled direction (§ 2). The year 2003 will be mainly dedicated to this problem and only the basic procedure is given here:

1. The foliage within a given crown will be described with 3 parameters: its total leaf area, its average LIDF[3] and a dumping factor. These parameters being quite dîfficult to assess, they will be fitted as described below.
2. A simple and easy to parameterise crown shape will be chosen (for instance the one represented on the figure 4). Sensitivity analysis will be then performed by varying the values of the 3 foliage parameters.
3. The value of the parameters will be selected in order to get the best fitting between the field measurements of light interception and the simulations.
4. The parameters fitted in that way (for the directions of in situ photographs) will be averaged for the population of sampled trees.

3 LIDF: Leaf Inclination Density Function

2. State of work

2.1. Field measurements

A first field measurement campaign was realised in Costa Rica between April 15 and July 15. The studied species were:

Cordia alliodora
Eucalyptus deglupta
Terminalia ivorensis
Terminalia amazonia
Cedrela odorata
Erythina sp.

The field measurements inc1uded the description of the tree crown (§ 1.1), snaphots of the tree silhouette (§ 1.2) and hemispherical photographs (§ 1.3). The measurement on *Cordia alliodora* were realized within the experimental plots of the CATIE. The measurements on *Terminalia amazonia* were realized within an experimental plot of iCAFE near San Isidro. The measurements on *Terminalia ivorensis* and *Eucalytus deglupta* were realized within the fincas Verde Vigor, Santa Fe and Weber at Pérez Zeled6n near San Isidro. For these species, the measurements were combined with measurements of biomass and leaf area effected by Sergio de Miguel.

2.2. Treatrnent of digital images

During the measurement campaign 601 photographs were made. Before their analysis, the images must be treated. Basically, the process can be resume to the following steps:

- Elimination of artefacts (c1eaning) such as superposing branches from other trees, landscape, etc.
- Delimiting the crown by tree silhouettes (§ 1.2)
- Simplification into a binary image (black and white)

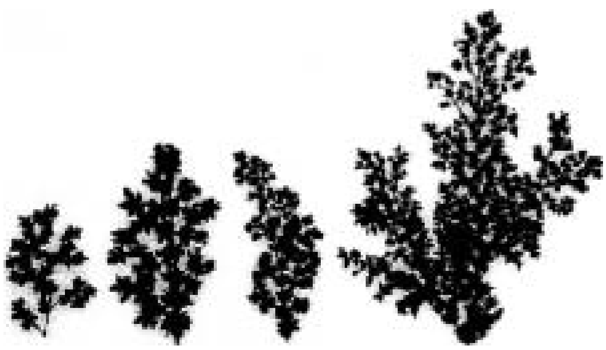
The main problem for delineating the silhouettes or cakulating the intercepting surface for Iight is the elimination of the background. As stated in §1.2, its not always possible to avoid such situations, specially inside the plot. Thus, the time necessary for the treatrnent of images varies strongly. Due to the site properties, the treatrnent of the species *Cordia alliodora* (118 images) and *Terminalia amazonia* (87 images) could be made in relatively short time -around lOto 20 minutes per image- as most of the photographs presented no or very few artefacts. For images presenting more artefacts, the image treatment took up to one hour.

In the case of *Eucalyptus deglupta* (140 images) a1most ail images presented a high proportion of artefacts, especially on the background. Sorne of the images couldn't be epurated and will be used only for determining the general shape of the tree. The time needed to c1ean such images can take over one hour and not less than 30 minutes

For *Terminalia ivorensis* (80 images), only single branches (one per disk) were photographed. In order to photograph them, the branches were held vertically trying to avoid having a busy background. Although this was not always possible, the treatrnent of the images was rapid, taking only 5 to 10 minutes per image and up to 30 minutes for the images with a complex background.

Figure 7:

branches of Terminalia Ivorensis



The size of each image was changed so that it matches the height and width of the visible crown in order to facilitate the analysis.

For hemispherical photographs, the main problem was due to the meteorological conditions when taking photographs. Literature recommendations restrict the practice of hemispherical photographs under conditions where diffuse light predominates in order to get a relatively plain and uniform background. For practical reasons (snapshots were taken at the same time as tree measurements) it was decided to take the photographs at any time with the only requirement that the direct sunlight must not enter the lens. Despite these conditions, the images could be treated with ad hoc combinations of RGB colour planes. In sorne cases, it was necessary to treat separately different zones within the image. For cloudy conditions with partly overcast sky, the steep contrast between the blue sky and the clouds also creates artefacts, which are however easily removed.

On the other hand, due to the lack of experience at the beginning of the measurement campaign, sorne hemispherical photographs were not correctly centred and oriented to the north direction, so that it was necessary to correct this during image treatment.

2.3. <u>Programming</u>

The MIR and MUSC prograrns (calculating respectively the interception of incident radiation and the multiple scattering within the canopy) have been rewrittten in C++ in environrnents Windows and Linux. The third module of the light model, RADBAL (combining the result of the first 2 modules to calculate the radiative budget within a stand according to the radiative conditions), must be rewritten during the first semester of 2003. It will then be possible to ron the whole software for radiative simulations on Personal Computers. An interface menu has also been developped for these prograrns.

Light interception in the coffee canopy

Dr. Philippe Vaast (ClRAD), Pablo Siles (CATIE) and Jobert Angrand (CATIE).

In collaboration with ClRAD (Dr. Ph. Vaast and Dr. 1. Dauzat), CICAFE (experimental site) and CATIE (M. Cervantes, P. Siles and J. Angrand), a lot of efforts have been dedicated in 2002 to measure light interception in the canopy of coffee trees under shade and full sun conditions. A sample of these results show that light intercepted by leaves was low in the interior of the canopy closed to the main stem, particularly the leaves 3 & 6 (see Annexes Fig. 1). They also illustrated that under 50% of shade, leaves of coffee received less than 400 µmol quanta $m^{-2}s^{-1}$ which is below the level of PAR (500-600 µmol quanta $m^{-2}s^{-1}$) where they achieve their maximum net photosynthesis (see Fig 6 in annexes of WP3 report); an indication that this shade level is probably too high. On the other hand, a large majority ofleaves ofsun-grown coffee received very high levels of PAR, above levels PAR (700-800 µmol quanta $m^{-2}s^{-1}$) where these leaves achieved their maximum net photosynthesis (see Fig 6 in annexes ofWP3 report).

Ali these measurements of light interception should help refming the 3-Dirnensional architectural model of coffee tree already in development (see Annexes Fig. 2).

More measurements will be performed in 2003 in a new trial established in October 2002 with a wider range of 4 uniform shade levels (no shade, 25%, 50% and 75%).

Transpiration of coffee and associated trees

Dr. Philippe Vaast (ClRAD), Rudi van Kanten (CATIE).

ClRAD and CATIE have been involved in collecting data on transpiration ofboth coffee and associated trees using sap flow measurements in the sub-optimal conditions of the southem part of Costa Rica characterized by hot days and a long dry season (see Annexes Fig 3).

These results show that coffee transpiration rate increased rapidly after sunset and decreased sharply in the afternoon after 2:00 PM (see Annexes Fig. 4). Especially during the rainy season, they also show that water consumption of coffee was significantly lower under shade of timber-trees, Eucalyptus deglupta or Terminalia ivorensis, than under the shade of leguminous service tree, Erytrhina poeppigiana or in full sun (see Annexes Fig. 4). This is an indication of lower heat stress of the coffee under shade. Water consumption of coffee was lower during the dry season that in the wet season pointing out to water limiting conditions during that period. These results demonstrated that daily coffee transpiration followed weil the calculated evapo-transpiration potential (Eto) calculated according to FAO recommendations (see Annexes Fig. 6A).

Observations on the daily pattern of water transpiration of the associated u'ees show that trees behaved differently between the dry and rainy period. Trees had a lower but more regular transpiration rate in the dry season than in the rainy season (see Annexes Fig. 5). During the rainy season, tree water consumption declined rather rapidly after 10:00 AM. With the exception of Terminalia ivorensis, these results demonstrated that daily tree transpiration followed weil the calculated Eto (see Annexes Fig. 6B).

Calculation of water consumption of the coffee-tree associations show that it was far higher than for coffee alone. Observations on soil water content in the top soil (the first 30 cm where most of coffee and tree roots are located) show that water availability did not decrease differently in the coffee AF systems than in full sun (see Annexes Fig. 7). In general, these results indicate a strong decrease of water availability during the dry season and suggest probable water competition during part of the year in other ecological zones with more limiting water conditions.

Planned activities in 2003

In 2003, intensive field measurements on light partitioning between coffee and trees will be pursued in several target coffee AF systems to refine the light model in development according to with the timetable of expected deliverables due in 2003:

- Comprehensive model oflight partitioning in coffee AF systems (24 Months)

Likewise, field measurements of soil water content and water consumption of coffee and trees in target coffee AF systems will be undertaken in order to comply with the timetable of expected deliverables:

- Water balance model at plot scale (36 Months)

ANNEXES

Figure 1: Light partitioning at the leaflevel in four strata (0: upper branch in position 7 from top, 1 midIle-upper branch from position 14, 2: middle-Iower branch in position 21; 4: lower branch in position 28) of coffee trees under shade (upper graphs) and in full sun (lower graphs).

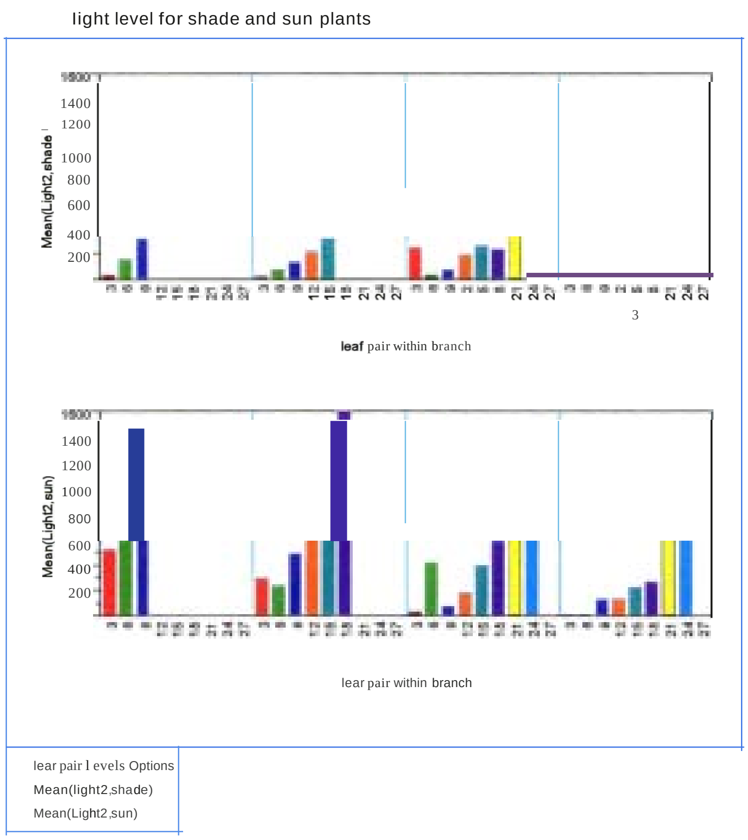


Figure 2: Schematic 3-dimensional representations oflight interception at the leaflevel in a young coffee tree at different periods during the day.

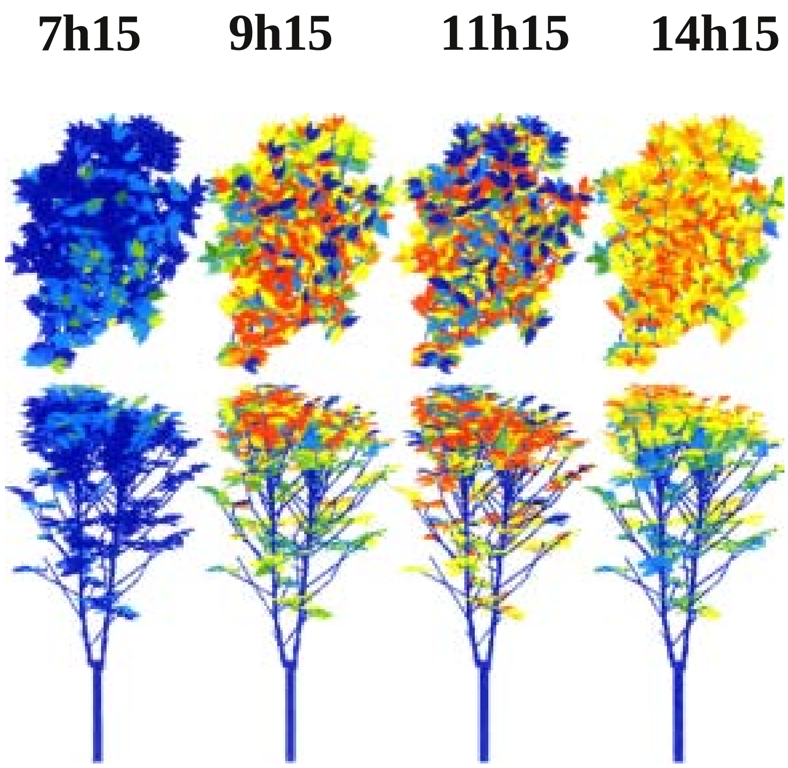


Fig 3. Mean air temperature T and total monthly rainfal1 P [3c] in Southern Costa Rica.

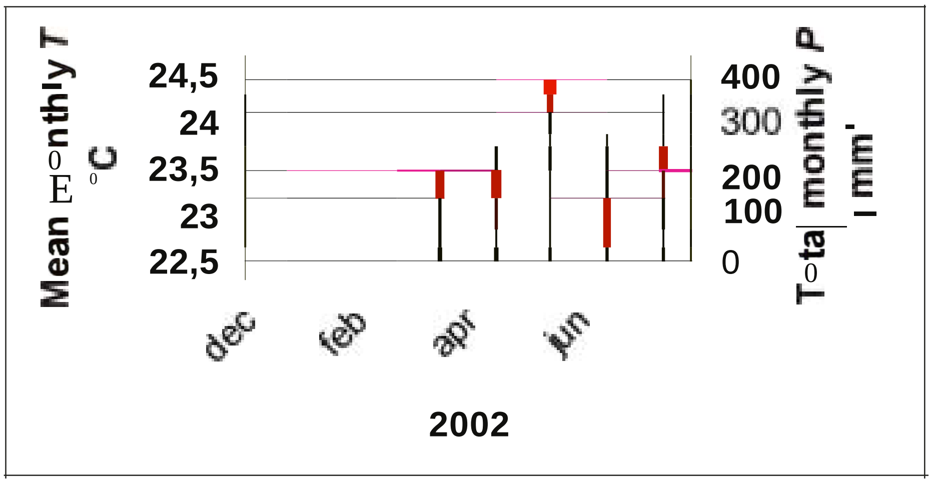


Figure 4. Daily pattern of coffee transpiration rate and air temperature T during the dry season (left) and rainy season (Right)

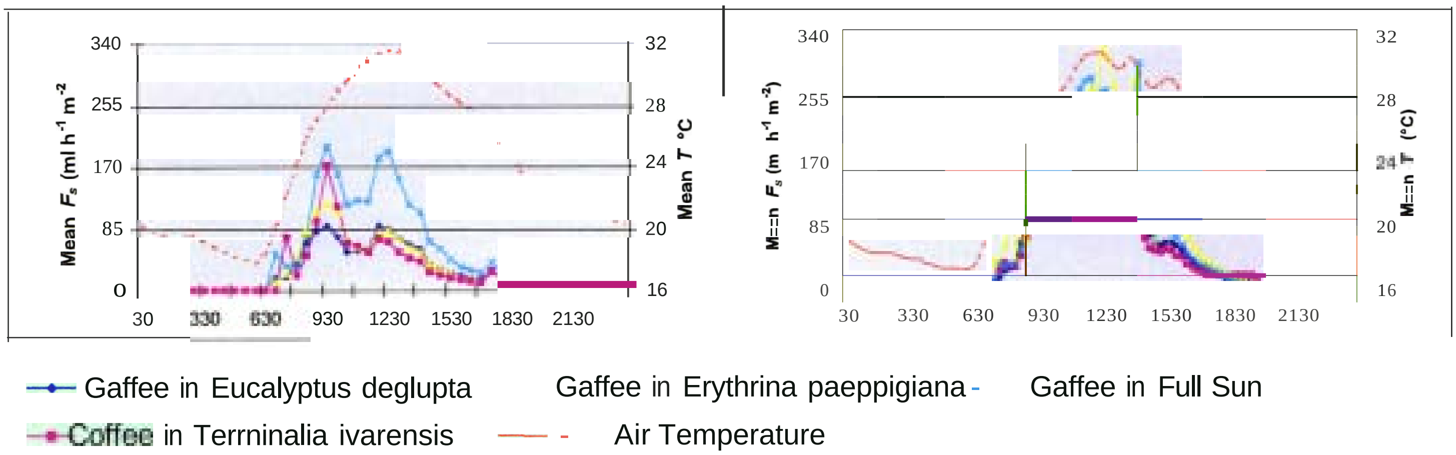
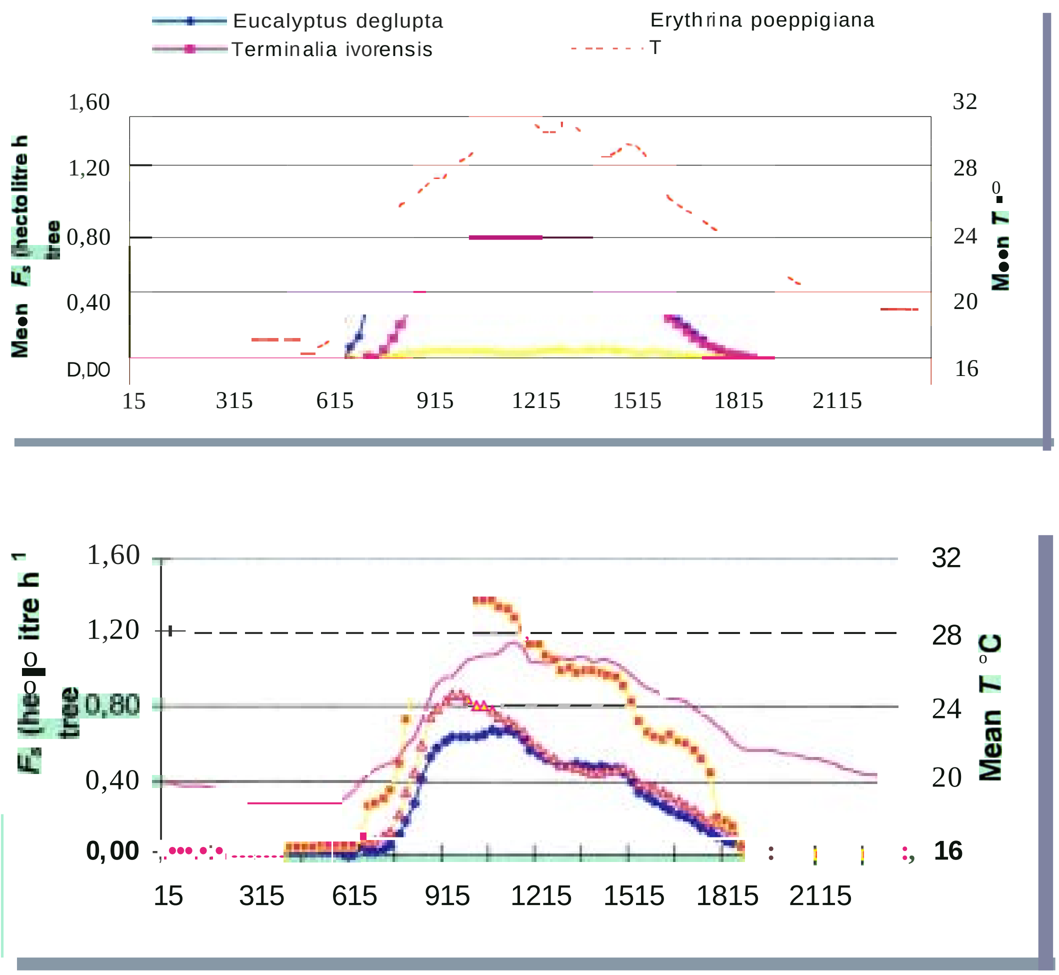
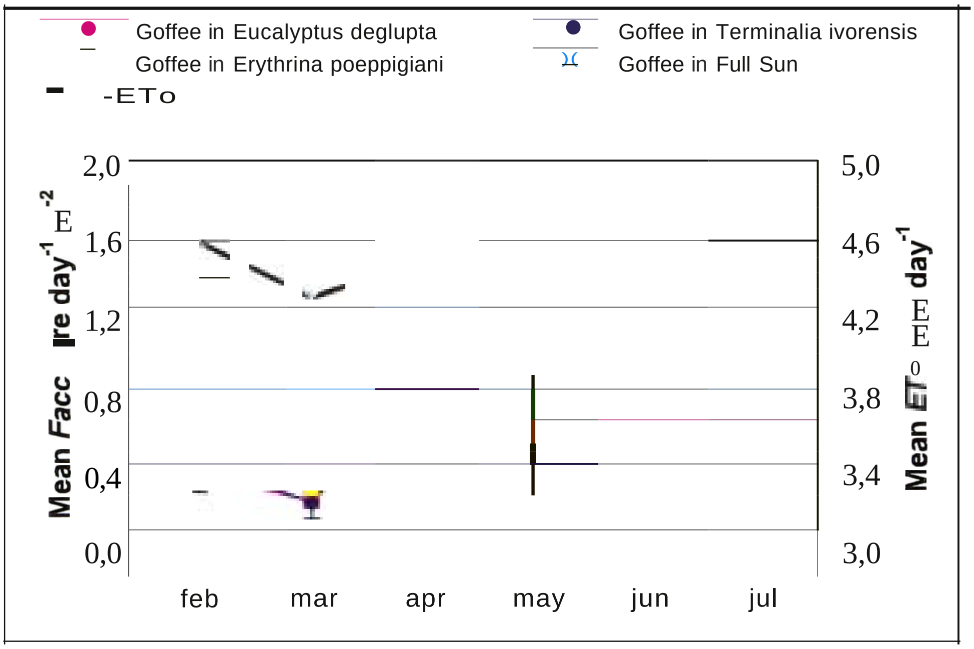
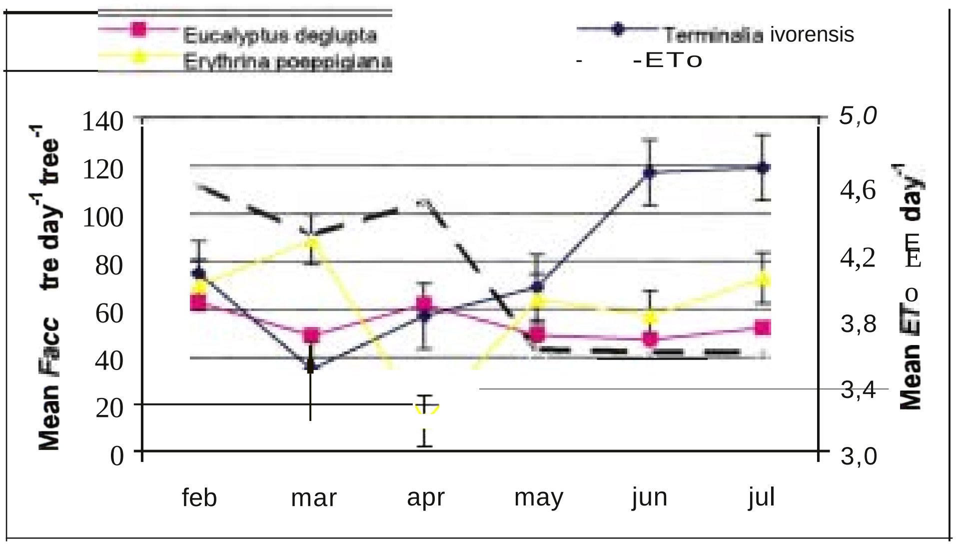


Figure 5. Daily pattern of tree transpiration rate (hectoliter H·[l] tree'l) and air temperature (T) during the dry season (upper graph) and rainy season (lower graph)







Figures 6 A and B. Mean daily coffee accumulated sap flow Face (s.e.) [Top Graph 6A] and mean tree Face (s.e.) [Bottom graph 6B] vs. mean Evapotranspiration ETo in Southern Costa Rica. Mean Facc's based on four-day periods every month and four trees and two coffee plants per treatment. Mean ETo and T based on four days.

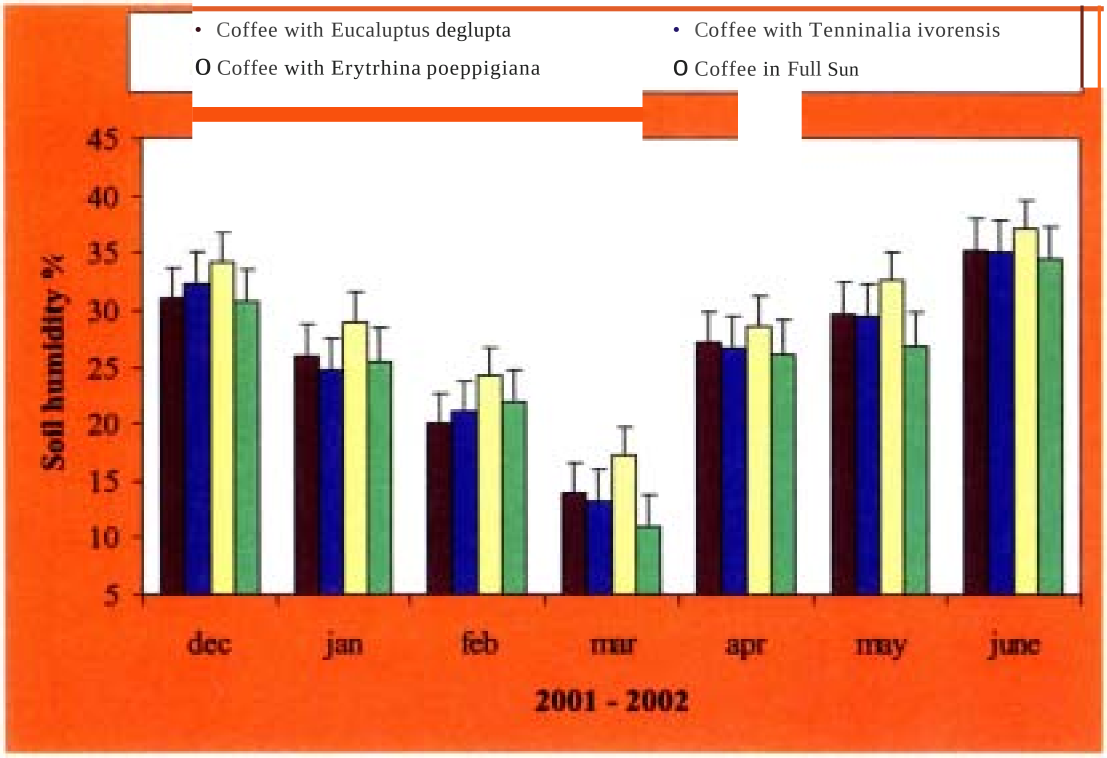


Fig 7. Mean soi! water content (%) (s.e., n = 16) in depth layer 0 - 30 cm in a sap flow trial in Southern Costa Rica.

CASCA

First Annual Report WORK PACKAGE 3

Dr. Philippe Vaast (CIRAD), leader ofWP3
Pablo Siles and Jobert Angrand (CATIE)

The objective ofthis present WP report is to highlight the main activities undertaken by all the partners of the project during the first year (November 2001 - October 2002) for the WORK PACKAGE **3:**

Coffee ecophysiology and quality

The main objectives ofthis WP3 are studying **physiological responses of coffee leaves** to micro-environmental field conditions, **developing a model of carbon production and allocation** in coffee plants as well as investigating the mechanisms responsible for **coffee quality.**

Field works have been undertaken:

- in two countries (Costa Rica and Nicaragua),
- 3 ecological zones (hot and dry lowland of the southem part of Nicaragua, optimal high-altitude zone of the central valley of Costa Rica, hot and humid low land of southem part of Costa Rica),
- and 5 different systems (coffee in full sun and coffee associated with either *Terminalia ivorensis*, or *Eucalyptus deglupta,* or *Erythrina poeppigiana*, or *Gliricidia sepium).*

Modeling of carbohydrate allocation

In all these systems, destructive samplings of fruiting branches have been performed to **quantify carbohydrate allocation** between fruits and vegetative part during the production cycle. These results show that coffee fruits are the most important plant sink for carbohydrates and out-compete other plant organs, especially branch apex in development. These results provide a better understanding on altemate production of coffee trees and die-back of branches in the presence of heavy fruit loads. More destructive samplings will be undertaken in 2003 to confirm these observations. Potential fruit and shoot growth rates were also are derived from these experiments as well as dynamics of leaf fall and ratios of fruit to leaf area. These measurements are being used to **parameterize a carbon model at the branch level** (article published in 2002 in Acta Horticultura). This model simulates the effects of different fruit load effects, shade, air temperature and water stress on fruit growth, carbon reserves and carbon partitioning between reproductive and vegetative components of a coffee branch over the whole production cycle (see annexes Figs 1 to 5).

Coffee physiology and microclimate effects

In collaboration between CIRAD, CrCAFE and CATIE, a lot of efforts have been dedicated in 2002 to measure **leaf and fruit photosynthesis** in optimal and sub-optimal conditions. These results show that leaf net photosynthesis reaches a plateau at less than half of the PAR registered in a cloudless day; shade leaves are more reactive at lower PAR, but reach their maximum net photosynthesis sooner and with lower values than sun leaves (see Annex Fig. 6).

These results demonstrate that leaf stomatal conductance and photosynthetic activity are at their highest during the early hours of the day and strongly decrease thereafter (see annexes Table 1). Preliminary observations on leaf exposition to different levels of solar radiation have been undertaken. They showed that high solar radiation induces rapid photo-inhibition. More observations on these aspects are planned in 2003.

Important results have been obtained regarding the effect of fruit load on leaf photosynthesis; it appears clearly that **presence of coffee fruit stimulates leaf photosynthesis** (see annex Table 2).

A first series of measurements on fruit photosynthesis has been undertaken in 2002. These preliminary results show that **fruit photosynthesis is far from negligible** and increases with increasing PAR (see Annex Fig. 7). Nevertheless, more data need to be collected in 2003 to get a better understanding of the coffee fruit contribution to its own carbohydrate demand over the whole production cycle.

Experiments comparing normal branches and with ring-barked branches have highlighted the fact that **transfer of carbohydrates seems important** and affects leaf photosynthesis (see annex table 3). This will be an important aspect to consider for the development of a carbon model at the whole plant level.

Microclimate at different levels in the coffee tree has been monitored in full sun and under shade conditions. Shade provided by trees creates more favorable microclimatic conditions for coffee, especially by decreasing temperature at the coffee leaf level and improving leaf photosynthesis (see annex of CATIE activity report).

Coffee quality

Data gathered from experiments show that fruit load and shade significantly affected coffee bean size and coffee quality. Position of fruits in the coffee tree canopy also affects coffee quality due to microclimatic differences and large differences in ratios of fruit to leaf area. More than 200 tests were performed by a panel of 8-10 tasters in the laboratory of CIRAD in Montpellier, France.

Lower fruit loads result in larger beans (see annex Table 4) and **higher quality** of coffee beverage; in general, the lower the fruit load, the higher the acidity of the beverage and the lower the beverage astringency (see annex Table 5). Effects on bean composition are less straightforward (see annex Table 6).

Shade, provided by trees or artificial cloth, lengthens by up to 6 weeks the maturation of coffee berries resulting in **better quality** of the coffee beverage with higher acidity and a higher preference on the part of the tasting panel (see annex table 7). Biochemical composition was also altered by shade (see annex table 8). Fat content of beans from shade coffee trees was higher than in sun-grown coffee; an indication of better bean filling. Trigollenine content of beans from sun-grown coffee was higher than in shade grown coffee; this relates weIl with the fact that coffee beverage from sun grown coffee tree was more bitter and more astringent.

In 2003, observations on these trials will be continued to confirm these results and improve our understanding of the mechanisms responsible for coffee quality. In a new trial just established in October 2002, the effect of 4 levels of artificial and uniform shade (no shade, 25%, 50% and 75%) on coffee quality will be monitored over the 2003 production cycle.

Planned activities in 2003:

A meeting is planned between Dr. Marcel van Oijen (CEH, leader of WP6) and two CIRAD scientists in June 2003 to finish editing the review of carbon allocation modelling approaches in fruit trees (deliverable due initially after 6 Months).

In 2003, intensive field measurements, as exposed earlier, are programmed during the whole coffee production cycle to comply with the timetable of expected deliverables due in 2003:

- Report on mIes of carbon allocation within coffee plant (20 Months)
- Scientific report on physiological responses of coffee to microclimatic conditions (20 Months)

ANNEXES

Figures 1, 2, 3 4 and 5: Simulations with the model RAMCAF regarding the fiuit load effects on fiuit growth (left), carbon reserves (middle) and carbon partitioning between reproductive and vegetative components of a coffee branch (right). Fruit loads are 25, 50, 150 & 250 berries per branch for treatments 1, 2, 3 and 4, respectively.

Fig. 1: Under control (optimal) conditions of the central valley in Costa Rica

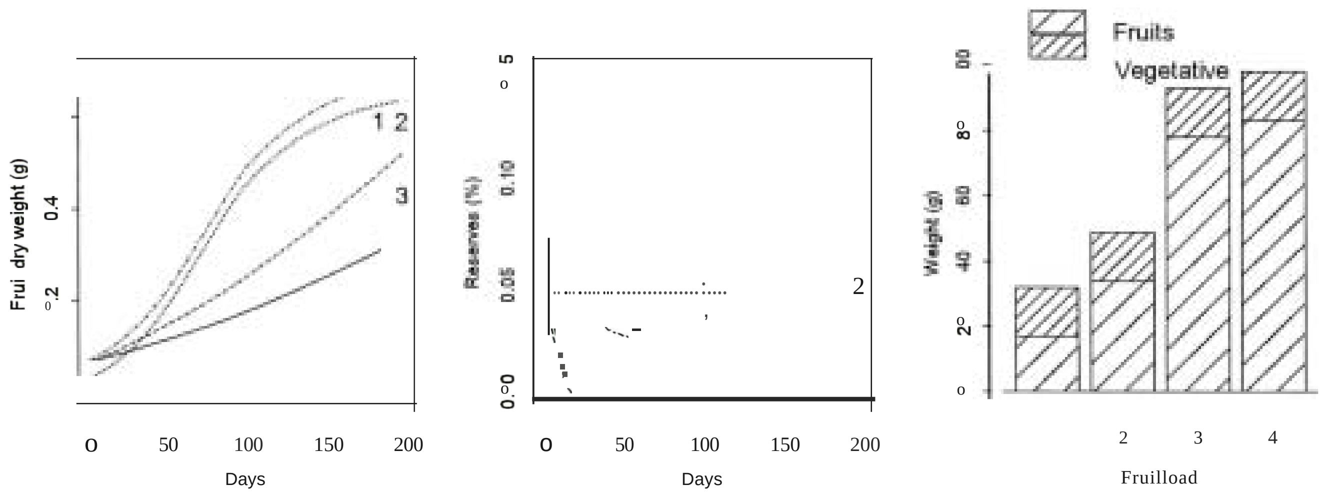


Fig. 2: With shade by a dense tree layer (allleaves submitted to 25 % of incident PAR)

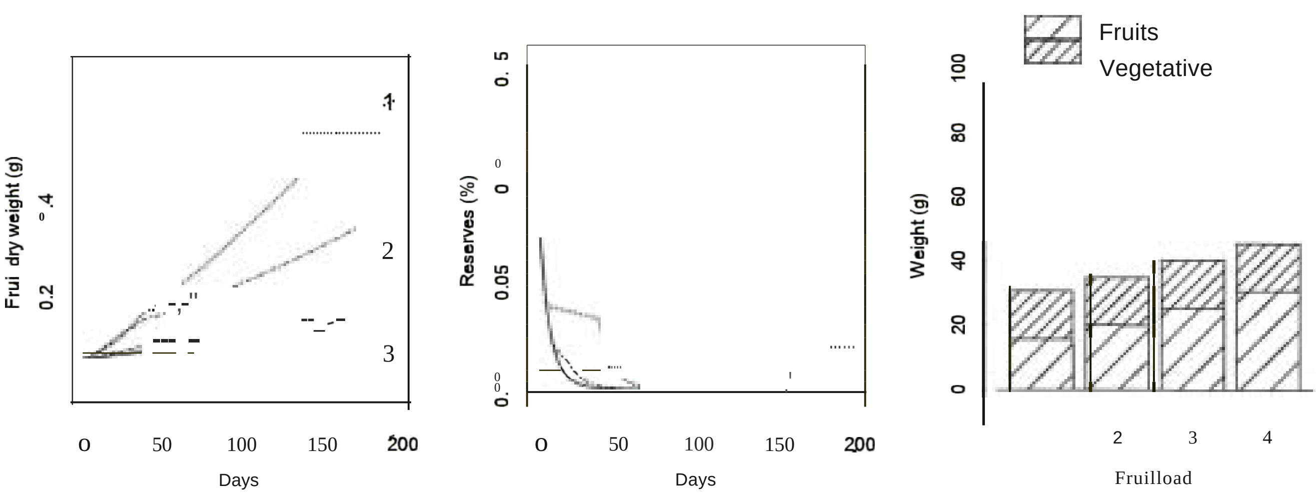


Fig. 3: With water stress (P = -2 bars during the first 50 days)

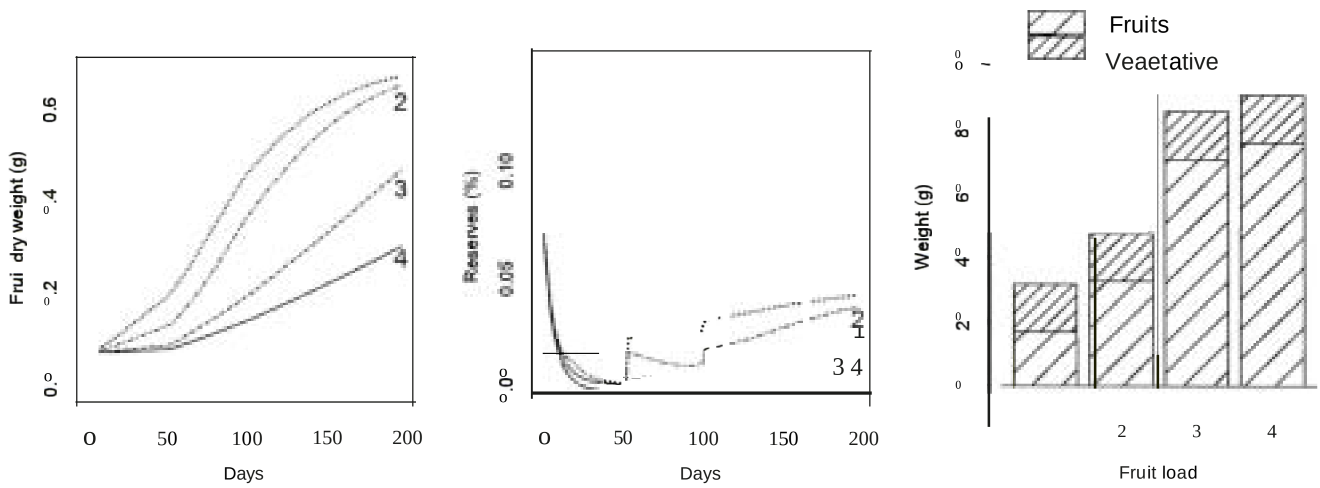


Fig. 4: With low (control - 2°C) temperature regimes

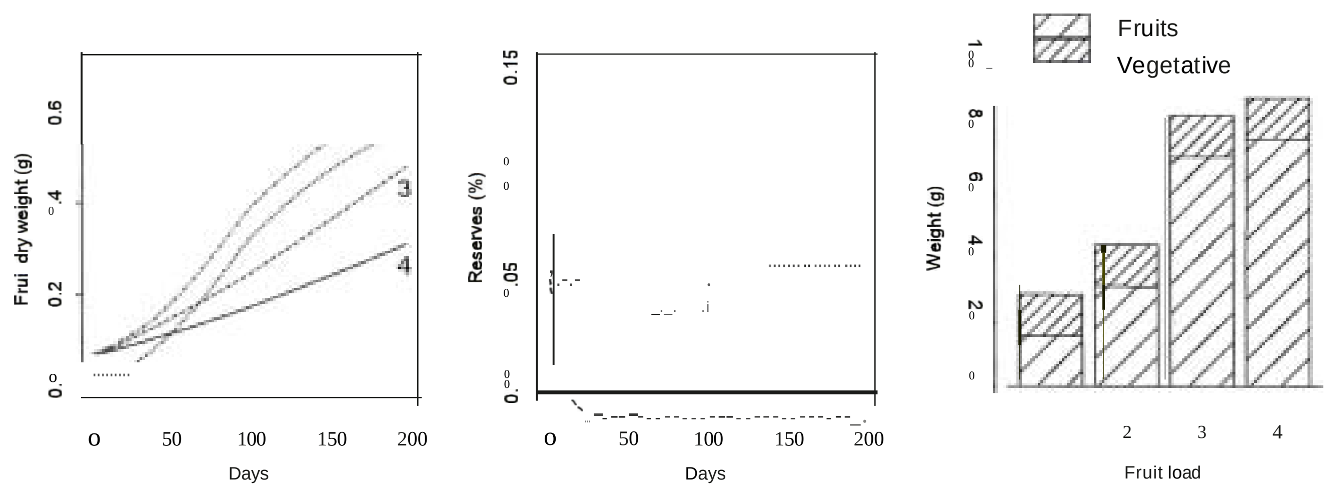


Fig. 5: With high (control + 4°C) temperature regimes

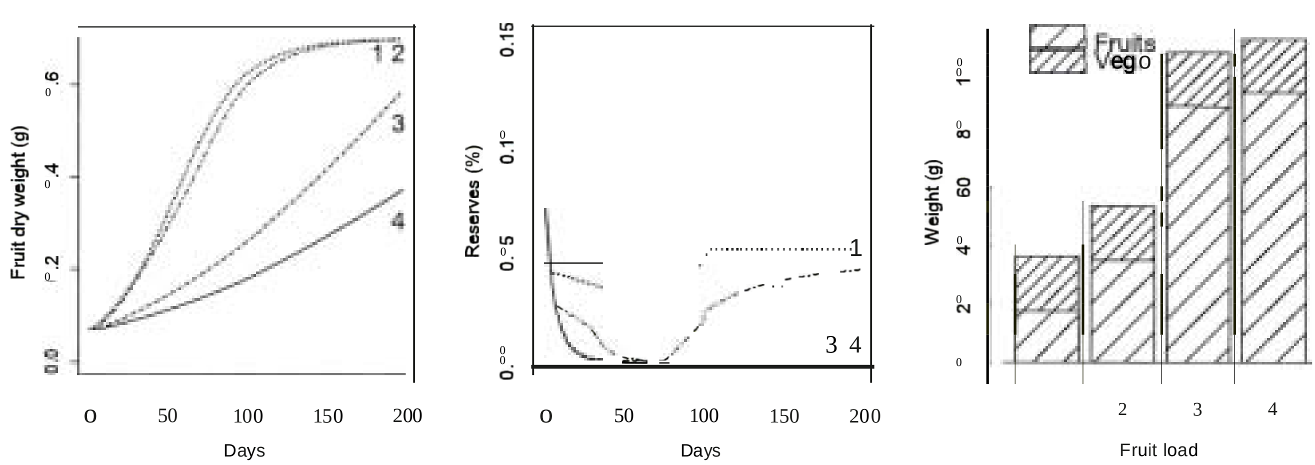


Table 1. Net Assimilation (µmol CO_2 $m^{-2}s^{-1}$) of coffee leaves as affected by the period of the day and level of PAR (µmol quanta $m^{-2}s^{-1}$) at a constant temperature of 27°C.

Period	Net coffee leaf assimilation (µmol CO_2 $m^{-2}s^{-1}$)	
	PAR 300 µmol quanta $m^{-2}s^{-1}$	**PAR 900 µmol quanta** $m^{-2}s^{-1}$
7:00 - 9:00 h	4.6 b	3.4 b
11:00 - 13:00 h	3.7a	4.1b
15:00 - 17:00 h	3.6 a	2.4 a
Pr> F	.021	.0002

Table 2. Net assimilation (µmol CO_2 $m^{-2}s^{-1}$) of coffee leaves as affected by fruit load and level of PAR (µmol quanta $m^{-2}s^{-1}$).

Fruit load	Net coffee leaf assimilation (µmol CO_2 $m^{-2}s^{-1}$)	
	PAR 300	PAR 900
Fullload 100%	4.8 c*	4.0 b
Load 50%	3.6 ab	4.1 b
Load 25%	4.3 bc	2.5 a
Load 0 %	3.1 a	2.5 a
Pr> F	.0003	.0001

Table 3. Net assimilation (µmol CO_2 $m^{-2}s^{-1}$) of coffee leaves as affected by fruit load and ring-bark of the branch (ring-bark: RB and non-ring-barked: NRB).

Load (%)	PAR 300 (µmol quanta $m^{-2}s^{-1}$)		PAR 900 (µmol quanta $m^{-2}s^{-1}$)	
	RB	NRB	RB	NRB
100	4.4 c*	5.25 c	4.2 c	3.8 b
50	3.0 b	4.2 ab	2.3 ab	2.6 a
25	3.7 bc	5.0 bc	3.8 b	4.0 bc
O	1.7 a	4.5ab	1.4a	3.7b
Pr> F	0.03	0.03	0.02	0.02

Fig. 6. Effects of PAR (PPFD in µmol quanta $m^{-2} s^{-1}$) on net photosynthesis of shade (black circle) and full sun (open circles) coffee leaves

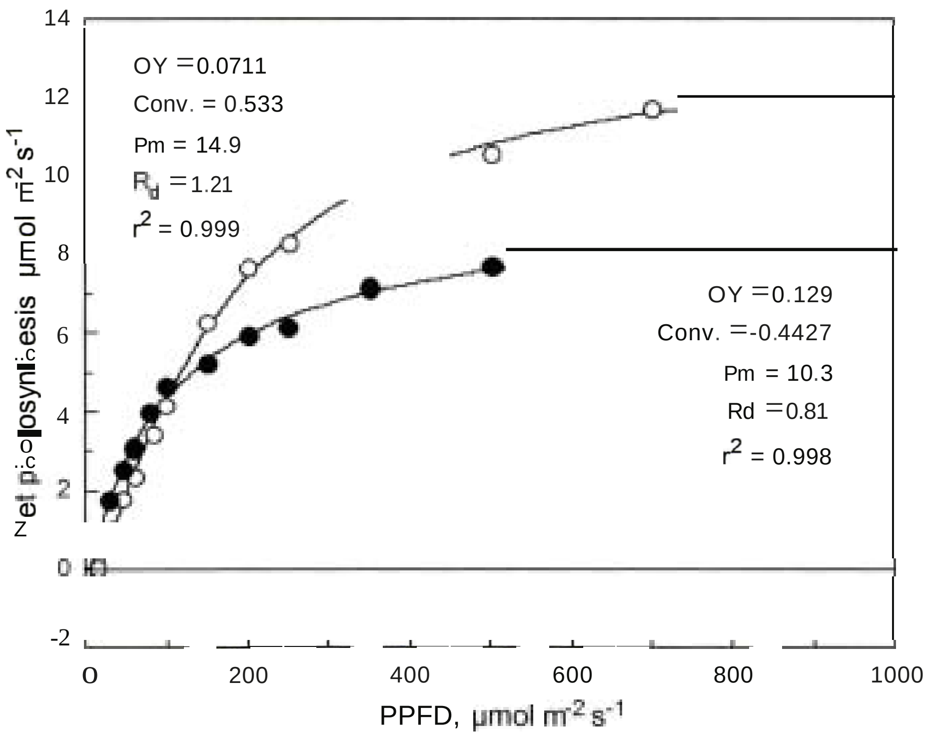


Fig. 7. Evolution of net assimilation (µmol CO_2 g-1 fresh fruit s-1) of attached green coffee berries on non ring-barked branches in response to increasing PAR .

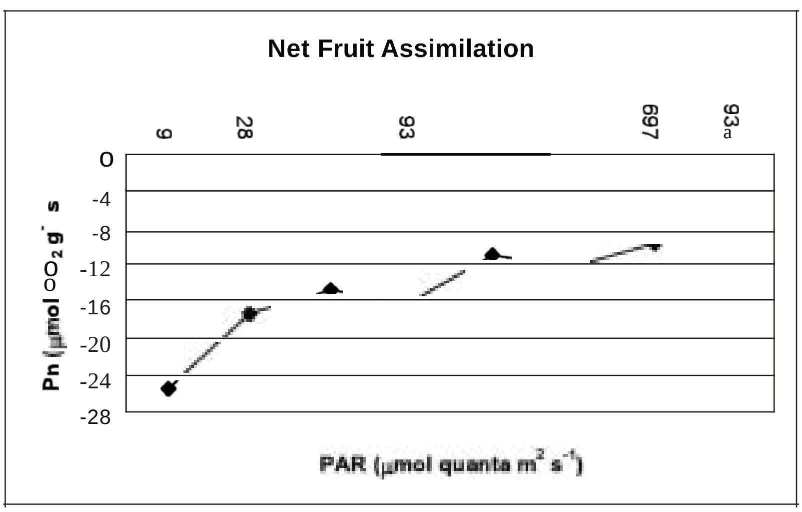


Table 4. Effects of fruit load (full: 100; half load : 50; and quarter load: 25) and canopy region (Higher part: U; Middle part: M; Lower part: L) on coffee production (Berry weight in g per plant) and bean size (weight of 100 fresh cherries in g) of plants grown in full sun.

Fruit load	100	50	25
Berry production	1305 a	718 b	487 b
Bean size	162 c	174 b	184 a
Canopy Region	H	M	L
Berry production	939 a	1329 a	240 b
Bean size	184 a	177 a	158 b

Table 5. Effects of fruit load (full: 100; halfload: 50; and quarter load: 25) and canopy region (Higher part: U; Middle part: M; Lower part: L) on sorne coffee bean tasting characteristics of plants grown in full sun.

Fruit load	100	50	25
Acidity	2.00 b	2.30 a	2.42 a
Bitterness	2.79 a	2.64 ab	2.46 b
Astringency	1.82 a	1.86 a	1.79 a
Body	2.92 a	2.94 a	2.72 b
Preference	2.44 b	2.64 ab	2.73a
Canopy Region	H	M	L
Acidity	2.18 b	2.17 b	2.36 a
Bitterness	2.64 a	2.59 a	2.68 a
Astringency	1.82 a	1.85 a	1.81 a
Body	2.86 a	2.87 a	2.84 a
Preference	2.65 a	2.42 b	2.74 a

The score for acidity, bittemess, astringency, body and overall quality was based on a scale of 0-5, where O=nill and 5=very strong. Each value is based on scoring by 10 judges.

Table 6: Effects of fruit load on coffee bean biochernical characteristics.

biochemical prop.	100	50	25
Cafeine (%)	1.43 b	1.45 a	1.46 a
Fat(%)	12.7 a	12.7 a	12.5 b
Saccharose (%)	8.3 a	8.3 a	8.4 a
Chlorogenic acid (%)	7.66 a	7.67 a	7.66 a
Trigonelline (%)	1.03 a	1.03 a	1.00 b

Table 7: Effects of shade on beverage characteristics.

Beverage quality	Shade	Sun
Addity	2.50 a	2.16 b
bitterness	2.65 b	2.88 a
astringency	0.29 b	0.41 a
Body	2.45 b	2.62 a
Preference	2.80 a	2.58 b

The score for acidity, bittemess, astringency, body and overall quality was based on a scale of 0-5, where O=nill and 5=very strong. Each value is based on scoring by 10 judges.

Table 8 : Influence of shade on coffee bean biochemical characteristics.

biochemical properties	Shade	Sun
Cafeine (%)	**1.48 a**	**1.42 b**
Fat (%)	**13.1 a**	**12.2 b**
Saccharose (%)	**8.2 b**	**8.4 a**
Chlorogenic add (%)	**7.62 b**	**7.71 a**
Trigonelline (%)	**0.99 b**	**1.07 a**

First Annual Report WORK PACKAGE 4

Jean-Michel Harmand (CIRAD), Vte Skiba (CEH Edinburgh, VK) and Victor Chaves (CICAFE, Costa Rica)

WP4 : Nitrogen cycling, leaching, uptake and emissions

The four objectives of the workpackage nitrogen cycling were:

- To improve nitrogen (N) management (N fertilisation, legume tree) by synchronising soil N availability to the needs of coffee and associated trees
- To measure key components of the N cycle, for 4 target coffee management systems, in field and laboratory conditions
- To elaborate a model of N cycling which predicts the losses and accumulation of nitrogen in different soil types and management systems
- To link N measurements to environmental evaluation at catchrnent scale

1. Nitrogen dynamics in a coffee agroforestry system with *Eucalyptus deglupta* in the south zone of Costa Rica

Jean-Michel Harmand (CIRAD/CATIE, Costa Rica), Hector Avila (CATIE, Costa Rica), Vanessa Reina Renderos (CATIE, Costa Rica), Etienne Dambrine (INRA, Nancy, France)

11. Introduction

In many areas, coffee is grown in intensive monocultures which are dependent on high inputs of fertilisers, pesticides and herbicides. Traditionally, more extensive multi-strata coffee agroforestry systems are used, in which shade trees are retained or deliberately introduced, to reduce management costs compared with high-input full-sun plantations and to diversify the farm production. Extensive plantations also have potential to produce a higher quality of bean, and this is a high priority of Central American coffee producing countries.

The aim of the proj ect is therefore to help reverse the CUITent trend of intensive coffee management practices into more sustainable ones of lower economic risk. Within this framework, the introduction of valuable timber trees with an acceptable reduction in coffee production can be promoted. As an example, for the last ten years, *Eucalyptus deglupta* was introduced by farmers in order to produce timber but without any elaborated knowledge of the interactions between coffee and associated trees.

12. Background and objectives

Nitrogen is the most limiting element for the productivity of coffee in agroforestry systems. The introduction of *Eucalyptus deglupta* increase normally total biomass production and evaporative demand of the system which could reduce N leaching. Nevertheless, *Eucalyptus deglupta* takes up nitrogen and may reduce soil N mineralisation which maya reduce N availability for the coffee plant.

In order to understand the interactions between coffee plants and timber trees in term of nitrogen use and environmental impacts, we want to study nitrogen fluxes, as inputs (N fertiliser), outputs (leaching, runoff, denitrification and harvest) and accumulation in soil and biomass, as well as internaI fluxes like soil N mineralisation.

1.3 Materiel and methods

During the first year of the project, an experimental design was established in the Santa Fe farm in the south zone of Costa Rica. The altitude is 600 masl, total annual rainfall is approximately 4030 mm and temperature averages n ,5°c. Two plots were identified: a full sun coffee plot of 14 years old, and an adjacent coffee plot shaded by *E. deglupta.* The timber tree of 7 years of age was planted 7 years after the coffee.

In 2002, the plots had received 200 kg N/ha in two applications: the 22^{nd} of May and the 10^{th} of August.

Throughout the year (from March 2002), mineralisation and nitrification of the soil N was studied via field incubations in the two systems. The 0-20 cm layer was sampled and placed in 12 PVC tubes for incubation in the field for one month. The mineraI N contents of the incubated soil and field soil were analysed monthly.

Soil solutions were sampled using porous ceramic cups (model tensionics). These porous-cup lysimeters were located at four depths: 30, 60 and 120 cm with six replications per plot and 200 cm with 4 replications per plot. The sampling interval was 10 days and the nitrate concentration of the sample was analysed.

In the shaded plantation the lysimeters and PVC tubes were placed at 2 m away from the stem of *Eucalyptus* trees.

For the moment, water drainage was calculated approximately from soil water content measurements and daily potential evapo-transpiration data.

Mineral N content of the soil (N-N03 and N-NH4) was measured down to 2m depth in order to explain the low values of nitrate concentration in the spring water found by Renderos et al. during the year 2001.

Daily runoff was measured from $1m^2$ plots (3 plots per treatment) from April to September 2002 and N-N03 and N-NH4 concentrations were analysed daily during lO days after fertilisation and after that every 15 days just for cumulative runoff.

Harvest of coffee beans was measured in three plots (12 m x 12 m) per treatment.

Aboveground biomass measurements were made as described in the WP5 (Carbone).

Results about N accumulation in biomass, N loss in runoff and harvest, are expected at the end of this year.

Denitrification was measured in 5 chambers in each treatment and results are presented in the following.

1.4 Results

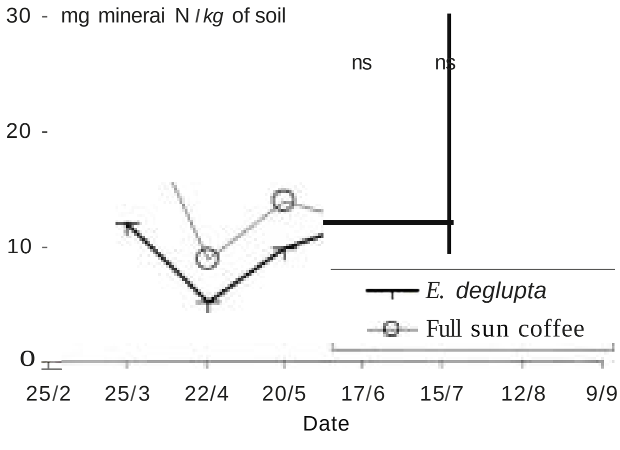
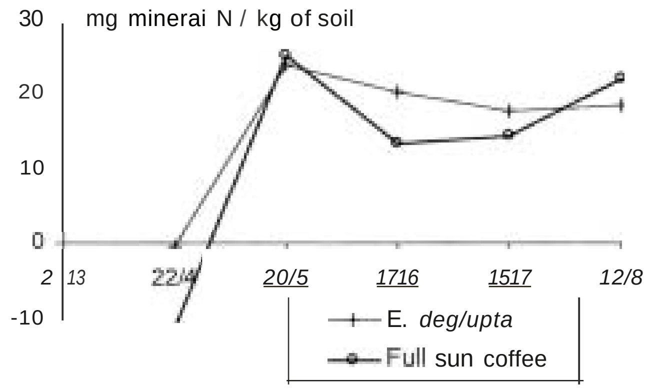


Figure 1: Dynamic of mineraI N (N-N03 + N-NH4) in the 0-20 cm soillayer. The signs **, *, ns indicate the significance level of the difference between the 2 treatments **: P=O.Ol; *: P=0,OS; ns: not significative

a) As showed in Figure 1, at the end of the dry season (2[od] of April) and during the beginning of the rainy season, the mineraI N content of the soil was lower under *E. deglupta* than in full sun coffee.In our site conditions, the main product of the process of mineralisation and nitrification of the organic N was nitrate (98% of total mineraI N). Futhermore, as showed in figure 2, *E. deglupta* had no depressive effect on soil N mineralisation (and nitrification) at the age of 7 years. So, the lower N mineraI content of the soil under the timber tree was due to the absorption of mineraI N by the tree species during the dry season and the beginning of the rainy season.



Cumulative N mineralisation from April ta August	*E. deg/upta*	Full sun coffee
kg N / ha	126	118

Figure 2 : Monthly soil N mineralisation in the 0-20 cm soil layer. There was no significant difference between the treatments for each incubation periad.

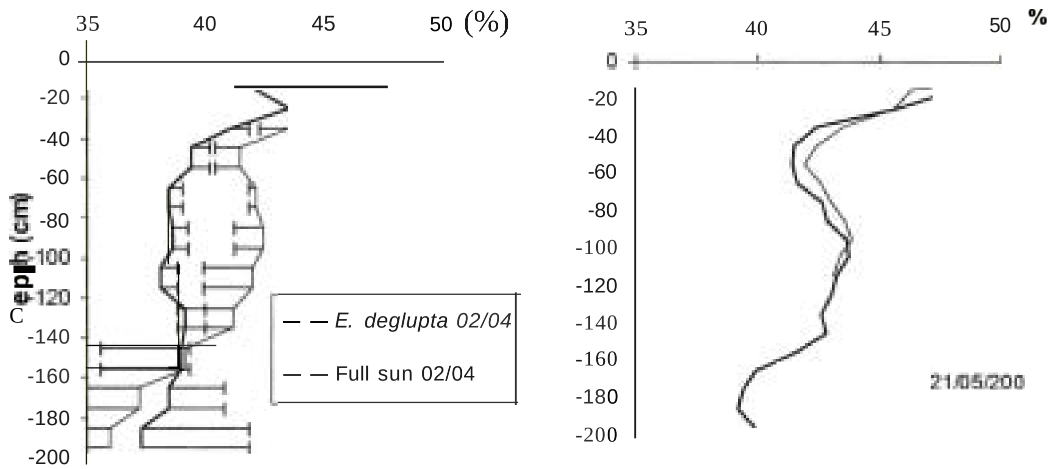
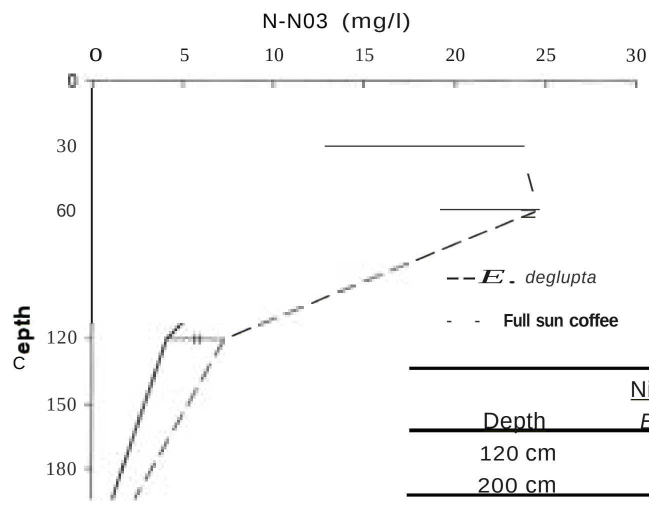


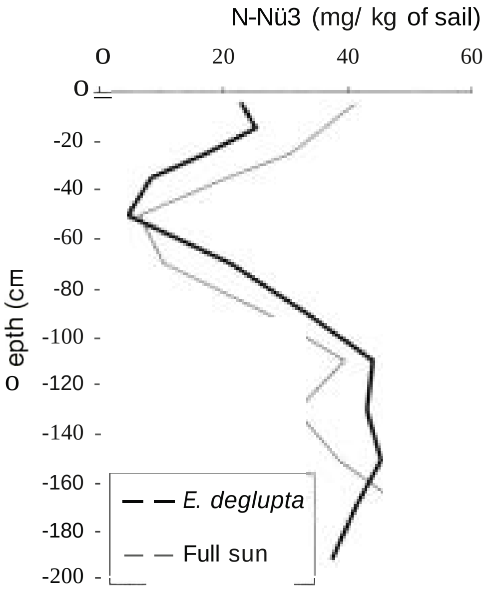
Figure 2: Soil moisture content at two dates : *02104* and 21/05 (% ofsoil weight).



Depth	Nitrate leaching (kg N / ha) *E. deg/upta*	Full sun
120 cm	20 '	41
200 cm	10	20

Figure 3 : Nitrate profile in drainage water (mg/l) and nitrate leaching (kg N/ha) from May to August 2002

b) The reduction of the soil moisture content (figure 2) under the tree during the dry season must be due to the increase in evaporative demand and that process could delay the refill of the soil water capacity and limit drainage and N leaching during the beginning of the rainy season. Furthermore, during the first period of the rainy season (May-August), in full sun coffee, drainage water was more concentrated in nitrates than under *E. deglupta,* (Figure 3) but the difference was significant only at 60 cm depth. A first estimate of the N losses by leaching for the two systems suggests that during the first period of the rainy season (from April to August) the full sun coffee system would loose 40 kg N/ha at 120 m depth : which represents the double quantity ofwhat would be lost in the shaded plantation (figure 3).



Sail nitrate accumulation (kg N-N03 / ha)		
Sail layer	*E. deglupta*	**Full** sun
0-60 cm	70	115
60-100 cm	105	80
100-200 cm	425	475
Total	**600**	**670**

Figure 4: Soil nitrate content at Santa Fe at the end of the dry season (02/04/2002)

c) The presence of positive charges (pH KCl > pH H_20) in the soil below lm depth could induce soil adsorption of nitrate ions, resulting in a great accumulation of nitrates in the soil (more than 400 kg ofN-N03 in the 100-200 cm layer as it is shown in figure4). This accumulation might result of years of fertilisation. The average fertilisation on this farm was 265 kg N/ha per year before 2000 and only 120 kg N/ha during 2001. The farm of Santa Fe is so large (1000 ha) and cultivated homogeneously in coffee under *Eucalyptus,* that land management on nitrate groundwater contamination can be estimated through spring water monitoring. In 2001, concentrations ofN-N03 along the year averaged 1.6 mg/l and did not exceed 5.8 mg/!. These low levels could be explained by soil adsorption processes which occurred at deep layers below 1 m depth. Lysimeters located 120 cm below the soil surface had higher mean N-N03 concentration (6.5 mg/l) than springs, suggesting also soil adsorption processes.

1.5 Conclusion

Sorne tentative conclusions from this first few months measurements are:

- *Eucalyptus deglupta* used as a shade tree in coffee plantations has no depressive effect on soil N mineralisation and nitrification at the age of 7 years.
- The timber tree may compete for mineraI N with coffee plants during the beginning of the rainy season.
- The timber tree increases the evaporative demand and reduces drainage and N leaching during the beginning of the rainy season.
- In the site of Santa Fe, nitrate adsorption in the soil potentially retards leaching of nitrates to groundwater.

2. Measnrements of nitrons oxide emissions from soil in coffee plantations, Costa Rica

Ute Skiba (CEH Edinburgh, UK), Pablo Siles (CATIE, Costa Rica), Jean-Michel Harmand (CIRAD/CATIE, Costa Rica)

21. Background and objectives

Nitrous oxide is a long-lived greenhouse gas, with a high global warming potential (1 molecule of N20 is equivalent to 250 molecules of carbon dioxide). The soil contributes to more than 60% of the total global emission ofN2ü.

In soil, the microbial processes nitrification and denitrification are responsible for N20 production. There are no non-biological processes in the soil known to produce this gas. Wet soils, high inputs of nitrogen, high soil pH, high carbon content are optimal for maximum N20 production and emission. Research by Babbar and Zak (J. Environ. QuaI 24, 1995) has shown that N2ü was the dominant product of denitrification in several coffee plantations in Costa Rica.

In the INCO/CASCA project we want to establish how much denitrification and N20 release occurs under different coffee management practices.

22. Progress of work

In the first year of the project measurements concentrated on designing, making and installing chambers for $N_2ü$ flux measurements at three locations in Costa Rica.

Sites:

a) At Paraiso 5 chambers were installed in an organic farm plantation (without any N fertiliser input for 10 years) on 17th June 2002. The parent material of the volcanic soil at Paraiso is basaIt.

b) On the 18/19 June 2002 chambers were installed in the Trial plots (full sun coffee) at CICAFE (Heredia) This trial is a block design of 4 blocks, containing 4 rates of fertiliser application (150, 250, 350, 0 kg N/ha/y) and 2 N fertiliser types (NH4N03 in granular form(G) or NH4N03 and urea as a liguid (L)). Chambers were also installed in the adjacent coffee/Inga and full sun coffee. Soil at Cicafe is an andisol containing vo1canic ash, slightly more sandy than the Paraiso soil.

c) On 21 and 22 June 2002 chambers (5/treatment) were installed at three sites: Coffee shaded by *E. deglupta* and full sun coffee with and without application of 200 kg N (as NH4N03) at SantaFe (San Isidro). Soil at Santa Fe is an ultisol

Measurements:
The N20 flux from soil was measured by the static chamber method. Gas samples are sent to Edinburgh, UK for analysis of by ECD gas chromatography. Aiso small soil samples are taken for analysis of soil moisture content and the soil temperature is recorded. Soil samples have also been taken from all sites for analysis of total denitrification, which will be carried out at Edinburgh.
Flux measurements were made from all sites in June immediately after installing the chambers. The influence of fertiliser application was studied at SantaFe in detail in August, and will also be studied at CrCAFE later this year.

Results:
a) Quality Control: l)The increase in N20 concentration inside the chambers is linear for at least a 2 hour enclosure period. 2) PTFE bags containing known concentrations of N20 (1 ppm) are shipped to and from Costa Rica in order to assess the N20 leakage rate.
b) Measurements of N20 fluxes from 3 locations in Costa Rica, June 2002 are summarized in Table 1. These data show, that
- Heavy soils at Paraiso and CrCAFE emit more N20 than the lighter soil at Santa Fe.
- At CrCAFE there is a linear relationship between N applied and N20 emission. More N20 is emitted from liquid than granular fertiliser.
- The influence of shade trees on N20 emissions may be different on a heavy and light soil.

Table l: Nitrous oxide emissions from coffee plantations in Costa Rica

		N_20 - N (ug lm^2/h^{-1})				
Location	Treatment	Mean	Stdev	Min	max	n
Paraiso 17.6.02	Organic	144.59	26.39	111.53	174.27	5
CICAFE 19.6.02	Control	118.39	16.20	99.73	128.79	3
	150 G	140.98	29.69	110.68	170.03	3
	250 G	157.58	25.23	126.22	178.18	4
	250 Gn	134.21		109.26	159.15	2
	350 G	175.82	23.21	155.21	200.96	3
	250 L	196.79	34.03	167.28	238.40	4
	Full sun (250)	114.86	18.48	93.64	127.38	3
	Inga (250)	86.02	12.61	68.21	95.56	4
SantaFe 21.6.02	Eucalyptus	29.56	25.54	9.02	73.30	5
	Full sun	6.48	2.28	5.05	9.10	3
	Control	41.44	52.39	7.46	119.52	4

(stdev = standard deviation o/the mean, min = minimum value, max = maximum value, n = number ofobservations)

c) The influence of fertiliser application on N20 emissions at Santa Fe was studied in detail. N fertiliser application increased N20 emissions from full sun coffee and coffee shaded by Eucalyptus in the first week after fertiliser application. (Figure 1).

The subsequent increase in N20 emissions from all plots coincided with increase in rainfall. The importance of rainfall on N20 emissions cannot be underestimated. The average N20 emission measured for this study period (Median flux in :g N/m2/h from 5 chambers on 7 dates): 29.7 for Eucalyptus + Coffee, 24.4 for full sun coffee and N fertiliser and 10.6 for full sun coffee without N fertiliser. The differences in N20 emission from full sun and shaded coffee plantations at Santa Fe observed in June (Table 1) was not confirmed in this study.

d) A fIfst estimate of the N losses by denitrification at the three study sites suggest that at Paraiso (organic farm) and Heredia (Cicafe) denitrification losses are of the order of 10 kg N /ha /y, whereas at Santa Fe only 2.5 kg N /ha /y is lost by denitrification.

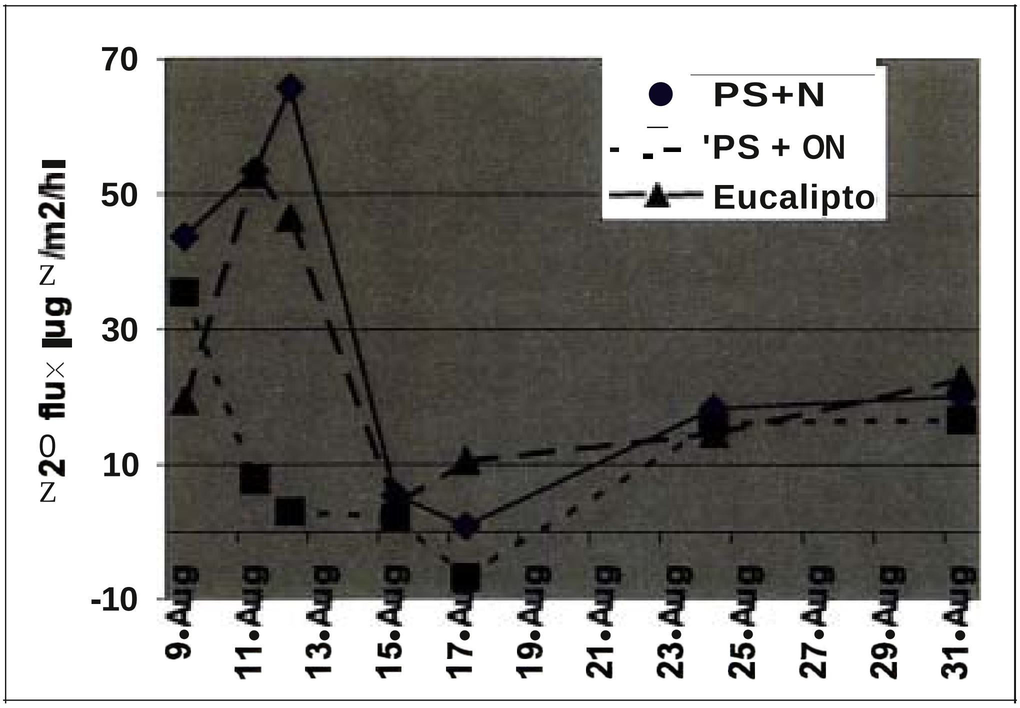


Figure 1: Nitrous oxide fluxes before and after N fertiliser application on 10 August, 2002 at Santa Fe

23.Conclusions

Sorne very tentative conc1usions from these early measurements are:

- N fertiliser additions stimulate N20 emissions, but soil type and rainfall patterns appear to be equally important in controlling emissions and N losses.
- The effect of shade trees on N20 emissions and N loss is inconc1usive.
- Denitrification losses from organic and conventional systems can be equally large.

3. Dinamica de nitrogeno en un sistema de café en relacion con la fertilizacion nitrogenada

Victor Chaves (CICAFE, Costa Rica), Jean-Michel Harmand (CIRAD/CATIE, Costa Rica)

31. Introduccion

Con el propôsito de evaluar en el cultivo de café la fertilizaciôn nitrogenada en relaciôn a dosis (150, 250 Y 350 Kg/ha/a), fuentes (Nitrato de Amonio en granulados y Vrea en liquido) y fraccionamiento (3 y 6 aplicaciones), se estableciô un ensayo en Barva de Heredia a 1180 msnm con el cultivar CR 95 manejado a plena exposiciôn solaro Los cafetos fueron sembrados en Agosto de 1997 a una distancia de siembra de 1,70 por 0.90 m y a dos platas por punto de siembra.
En 1998 se iniciô la aplicaciôn diferencial de las fuentes y su fraccionamiento, empleandose en todas las parcelas una dosis uniforme de 150 kg/ha/a; la que a partir de 1999 fue variada de acuerdo a los tratamientos. Lo que se plantee hacer en el proyecto CASCA con este ensayo es valuar la inf1uencia de la fertilizaciôn nitrogenada sobre la disponibilidad de nitrôgeno en el suelo, la absorciôn de nitrôgeno por la planta de café, la producciôn de grano y las perdidas de nitrôgeno par lixiviaciôn y denitrificaciôn.

32. Material y métodos

El ensayo es un ensayo en bloque completa que tiene 4 repeticiones.
Al fin de cuantificar la acumulaciôn de N en los diferentes tratamientos al fin de la estaciôn seca, de 16 plantas que componen la parcela útil se podaron 4 en Mayo 2002, midiéndose en ellas la biomasa y concentraciôn de nitrôgeno.

33. Resultados

a) Producciôn de frutos de café

En el Cuadro Ise presentan los resultados de las tres cosechas de frutos de café. En relaciôn a las fuentes, el Nitrato de Amonio superô significativamente al *VAN* en dos de las tres cosechas, asi coma en el promedio. Eso ensefia la menor eficiencia de la formula liquida. Por otra parte no hubo diferencias significativas para el fraccionamiento pero si para las dosis, superando el nivel de 350 kg/ha a las dosis menores, tanto en la segunda cosecha coma en el promedio.
Pero el aumento de la dosis de fertilizante de 200 kg/ha (150 hasta 350 kg N/ha) contribuyô solamente a aumentar la producciôn de frutos de 12%. Si se toma en cuenta solamente el fertilizante granulado(nitrato de amonio) el aumento de producciôn de frutos seria solamente de 7% (73,4 hasta 81 fanegas/ha).

Cuadro 1. Cosechas evaluadas en Fa/ha.

	99/00	00/01	01/02	Promedio
Fuentes				
Nitrato de Amonio	100,5 a	64,4 a	78,2 fis	80,7 a
UAN	89,1 b	47,9 b	76,5	70,8 b
Fraccionamiento				
3 Aplicaciones	92,8 ns	57,9 ns	77,0 ns	75,6 ns
6 Aplicaciones	96,8	54,4	77,6	75,9
Dosis (				
150	96,4 ns	40,4 b	81,9 ns	72,6 b
250	90,0	58,1 b	73,5	73,5 b
350	98,1	69,8 a	76,6	81,2 a

b) Biomasa y N almacenado

Los resultados parciales indican una relaci6n linear entre las dosis de fertilizante aplicado y la biomasa aérea deI cafeto al fin de la estaci6n seca. Hubo diferencia significativa entre las dosis unicamente por los frutos que eran poco desarrollados en este momento.

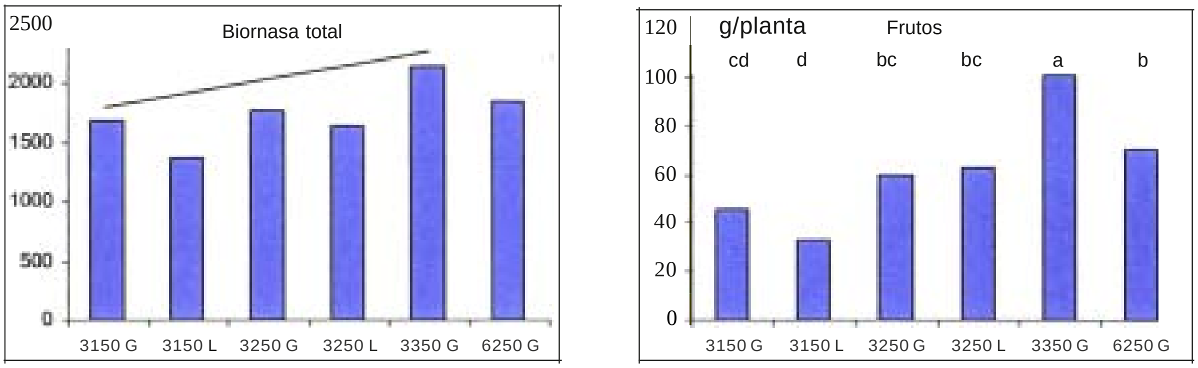


Figura 1: Biomasa total y de los fiutos por cada planta al fin de la estaci6n seca (Mayo)

3) Analisis de suelos

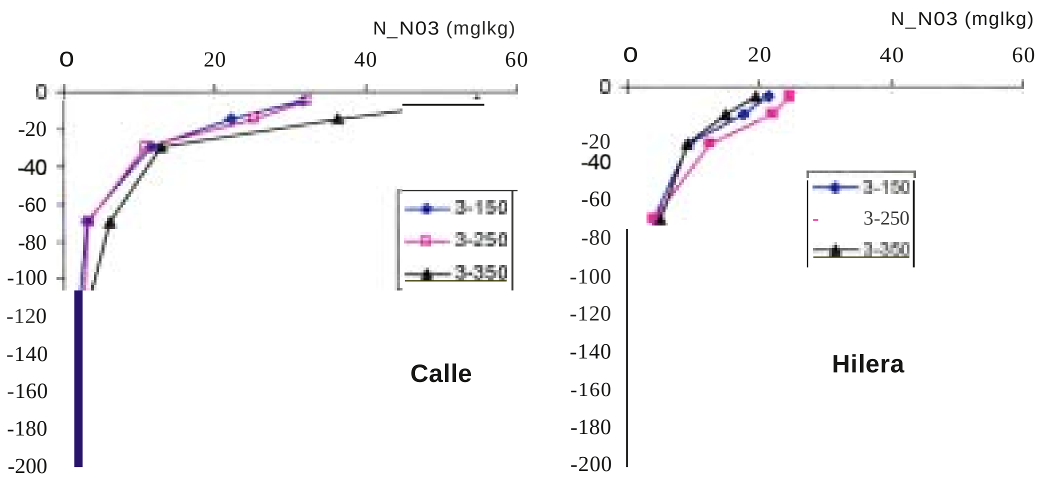


Figura 2: Contenidos de nitratos en el perfil de suelo en Heredia al fin de la estacion seca

Los análisis de nitratos en el suelo al final de la estaci6n seca (Mayo 2002) indicaron que en contra de los ultisols de San Isidro, no hubo acumulaci6n de nitratos en la capas profundas deI suelo. Entonces, en este tipo de suelo, los productos de lixiviaci6n deben salir rapidamente hacia la tabla freatica. La acumulaci6n de nitratos en la capa superficial deI suelo fue debida a la fertilizaci6n de octubre - noviembre al final de la estaci6n lluviosa. No hubo diferencia significativa entre los tratarnientos. Las tendencias eran :(1) una acumulaci6n mas grande de nitratos entre las hileras que sobre la hilera debido a la falta de absorci6n de parte de los cafetos lejos de sus pies, (2) una acumulaci6n más grande en la dosis maxima.

En el Cuadro 3 se presentan los resultados de un analisis de suelo realizado en Febrero de 2001, observandose aumento de la acidez (H+AI) y una progresiva disminuci6n en el contenido de bases conforme aumenta la dosis deI fertilizante nitrogenado.

Cuadro 3. Amilisis de suelo. Febrero, 2001

Fuente y Dosis	pH	acidez	K	Ca	Mg	SC
150 N.A.	4,79	1,93	0,59	2,66	1,32	4,56
250 N.A.	4,50	2,80	0,44	1,60	0,79	2,83
350 N.A.	4,37	3,17	0,41	1,43	0,68	2,52
X	4,55	2,63	0,48	1,90	0,93	3,30
150 UAN	4,52	2,83	0,45	1,50	0,87	2,83
250 UAN	4,41	3,10	0,42	1,53	0,82	2,76
350 UAN	4,30	3,45	0,39	1,23	0,66	2,29
X	4,41	3,13	0,42	1,42	0,79	2,63

34. Conclusion

De los primeros resultados deI ensayo, aparece que cuando se aumenta la dosis de fertilizante granulado de 150 hasta 350 kg N !ha, la ganancia media de producci6n puede ser minima (+7%). Si este aumento esta justificado econ6micamente en un contexto favorable de venta deI café, el impacto negativo sobre el ambiente esta preocupante, especialmente en termino de acidificaci6n y de empobrecimiento deI sue10 en bases.

Para evaluar realmente el impacto ambiental y la viabilidad econ6mica de los diferentes nive1es de fertilizaci6n nitrogenada, se sacarán más resultados en los pr6ximos afios, sobre absorci6n de nitr6geno por la planta de café, producci6n de grano y perdidas de nitr6geno por lixiviaci6n y denitrificaci6n.

Article (to be published in December 2002):

Reina Vanessa Renderos Durán, Jean-Michel Harmand, Francisco Jiménez, Donald Kass *(2002).Sistemas agroforestales café-eucalipto* (Eucalyptus deglupta) *y contaminacion deI agua con nitratos en microcuencas de la Zona Sur de Costa Rica* Agroforesteria en las Americas

Tesis:

Reina Vanessa Renderos Durán
Efecto de sistemas agroforestales *café-Eucalyptus deglupta* sobre la contaminaci6n deI agua con nitratos en microcuencas de la Zona Sur de Costa Rica. CATIE Turrialba, Costa Rica 2001 .

WP5 : Secuestro de carbono por sistemas agroforestales con café

Elaborado por Dr. Jean-Michel Harmand (CIRAD), Kristell Hergoualc'h (CATIE) y Sergio de Miguel (estudiente CIRAD)

Los tres objetivos planteados por el componente "secuestro de carbono" eran :

- Elaborar una base de datos y un modelo descriptivo deI secuestro de carbono en sistemas de café en América Central
- Mejorar la comprensi6n de las dinamicas deI carbono en la biomasa y la materia organica deI suelo de diferentes sistemas de café
- Extrapolar al nivel regional simulaciones deI secuestro de carbono en los diferentes sistemas de café hechas a nivel de la parcela

1. Elaboracion de una base de datos sobre almacenamiento y flujos de carbono en sistemas agroforestales con café

Hergoualc'h Kristell (CATIE, Costa Rica)

11. Introducci6n

Este trabajo es una sintesis de los datos existentes sobre almacenamiento de carbono en el suelo y en las plantas de sistemas agroforestales con café. Las cantidades almacenadas dependen principalmente de las densidades y edades de las especies, deI tipo de suelo, de las condiciones climáticas, deI a1titud, deI manejo agricola actual y deI uso anterior de la tierra. También se inc1uyen datos de flujos de carbono. El objetivo es de elaborar un modelo descriptivo deI secuestro de carbono en sistemas agroforestales con café.

12. Estructura y disefio de la base de datos

Formato: La base de datos está en formato Access 97.

Listado y descripci6n de las tablas

Cada estudio está descripto mediante 8 tablas:

- Tabla de *referencia dei estudio* (T_Fuente): Referencias deI estudio: autor, titulo, tipo (libro, tesis de maestria, etc).
- Tabla de *Autores* (T_Autor):Autor(es) deI estudio y senas.
- Tabla de *referencias geográficas* (T_Sitio): Descripci6n geografica y biofisica (lluvia, temperatura, zona de vida, etc.) deI sitio de estudio
- Tabla de la *unidad de estudio_(T_Parcela):* Descripci6n de la parcela 6 unidad de estudio: tamano, textura deI suelo, densidad y tipo de especies.
- Tabla de resultados sobre *almacenamiento de carbono* (T_AlmacenamientoCarbono): Contenido de carbono almacenado en las diferentes partes (follaje, ramas, tallos, raices, etc.) para cada especie deI sistema de estudio.
- Tabla de resu1tados sobre *Biomasa* (T_Biomasa): Biomasa por parte (follaje, ramas, tallos, raices, etc.) para cada especie deI sistema de estudio.
- Tabla de resu1tados de *flujos* (T_Flujos): Flujos de biomasa (caida de hojarasca, poda, cosecha, etc.) para cada especie.

Tabla de *metodologia* por resultado (T_Metodologia):Metodologia empleada para cada tipo de resultado obtenido: numeros, profundidades e instrumentos de muestreo, modelos, ajustes modelos, etc.

Relaciones entre tablas

Las relaciones entre tablas pueden ser de varios a varios ó de uno a varios.
Ej. de una relaciôn "varios a varios": Un autor puede estar presente en varias fuentes al igual que una fuente puede tener varios autores.
Ej. 2 de una relaciôn "uno a varios": en una parcela podremos tener varios estudios de almacenamiento de carbono (para diferentes aïios por ejemplo) sin embargo un estudio de almacenamiento hace referencia a una y una sola parcela ó unidad de estudio.

13. Estudios entrados en la base de datos

Once estudios están por ahora entrados en la base de datos. Seis estudios fueron hechos en Costa Rica, dos en Guatemala, dos en México y uno en Brasil.

14. VisualizacÎôn de las salidas de la base

Todos los resultados están expresados en cantidades de carbono: en [t/ha] cuando se trata de un almacenamiento, en [t1ha/ano] cuando se habla de un flujo.
Para ello, los resultados de todos los estudios de biomasa fueron multiplicados por un factor de 0,48 (promedio deI contenido de carbono en la materia orgánica según "Modelos Edafolôgicos de sistemas agroforestales segunda ediciôn, 1993, Fassbender, p. 173").

Salidas de la base de datos

Tenemos:

- 2 tipos de salidas: *por estudio* ó comparando *varios estudios*
- 3 salidas para cada tipo:
  - Reparticiôn *detallada* (cafetos, arboles, malezas, mantillo, raices) deI carbono almacenado en el sistema.
  - Reparticiôn *simplificada* (arriba deI suelo, suelo, raices) deI carbono almacenado en el sistema.
  - Flujos de carbono para las diferentes *especies* (cafetos, árbol especie 1, árbol especie 2) deI sistema.

15. Resultados

De los Il estudios entrados en la base de datos se pueden sacar las conclusiones siguientes.
Almacenamiento de carbono:

El carbono almacenado por los arboles depende mucho de la especie, de la densidad, de la edad de los arboles y no supera las 30 tlha.
El carbono almacenado por los cafetos no supera las 10 t/ha para especies arabicas y densidades de 4000 a 5000 cafetos/ha.
El carbono almacenado arriba deI suelo no supera las 80 t/ha.
El carbono almacenado en el suelo puede alcanzar 220 t/ha.

Flujos de carbono en el sistema:

La Poda (3 podas/afio) de la especie leguminosa *Erythrina poeppigiana* (muy frecuente en cafetales de Costa Rica) puede alcanzar 9 t/ha/afio.

La caida de hojarasca en un sistema café- *E. poeppigiana*- *Cordia alliodora* ó café- *E. poeppigiana* llega hasta 4 t/ha/afio.
La tasa de crecimiento aéreo deI cafeto se encuentra dentro deI rango 0,5-1,5 t/ha/afio y de la *E. poeppigiana* dentro deI rango 1-3 t/ha/afio.

1.6 Evolucion y mejoras de la base de datos

Esta previsto entrar mâs estudios tantos bibliogrâficos coma aquellos realizados en el marco deI proyecto CASCA y poner en linea la base de datos con acceso restringido para los datos no publicados.
La base de datos se extenderâ a otros sistemas (sistemas silvopastoriles, plantaciones, bosques) con el objetivo de comparar la dinâmica deI carbono deI sistema agrofarestal cafetalero con la de otros sistemas. Esta extension incluirâ el agrego de una tabla que registre especies de ârboles y sus respectivas ecuaciones alométricas para estimacion de biomasa/carbono almacenado.

2. Dinámica de la biomasa en un sistema de café con *Eucalyptus deglupta* en la zona Sur de Costa Rica

De Miguel Magana Sergio (ENGREF, France), Harmand Jean-Michel (CIRAD/CATIE, Costa Rica)

21. Introduccion

Entre las altemativas que se proponen para intentar paliar la crisis que afecta, desde hace ya un tiempo, al sector deI café, se ha planteado la adopcion de politicas que tengan en cuenta el pago par captacion y almacenamiento de carbono (Mecanismo de Desarrollo Limpio deI Protocolo de Kioto) y la produccion de madera a partir de los ârboles de sombra. Desde esta perspectiva, la especie *E. deglupta* destaca par sus caracteristicas morfologicas, la calidad de su madera tanto para fines industriales coma de produccion de lefia, ademâs de ser considerada una melifera excelente. Todas estas caracteristicas unidas a la forma de su copa, que procura una sombra favorable para la produccion de café, la convierten en una especie realmente interesante coma ârbol de sombra en los cafetales. Los objetivos deI estudio eran los siguientes: (1) establecer relaciones alométricas que permitan la estimacion de la biomasa deI sistema de café asociado con *E. deglupta* utilizando un parâmetro fâcil de medir en el campo; (2) estudiar la dinâmica de la biomasa deI sistema a 10 largo deI tiempo utilizando una cronosecuencia de rodales de café con eucalipto.

22. Material y métodos

El estudio se realizo en dos fincas cafetaleras (Verde Vigor y Santa Fé) ubicadas 20 kilometros al Sur de la ciudad de San Isidro deI General, en el canton de Pérez Zeledon, Costa Rica. Geogrâficamente, las fincas se encuentran entre las coordenadas 9°15' - 9°18' de latitud Norte y 83°31' - 83°36' de longitud Geste, con altitudes entre 600 y 700 msnm. La precipitacion anual es de 3853 mm en Verde Vigor y de 4039 mm en Santa Fé. El trabajo de campo para la toma de datos se realizo entre los meses de maya y julio de 2002. Para el establecimiento de la cronosecuencia se identificaron, en la finca Verde Vigor, parcelas en las que tanto los cafetos coma los eucaliptos tuvieran 2, 4, 6 Y 7 afios de edad. Los ârboles de sombra tenian una densidad de plantacion de 278 pies/ha hasta los 4 afios de edad y, posteriormente, 120 pies/ha debido al raleo que se practico al cuarto afio. La densidad de los cafetos estaba situada entre 4300 y 4450 plantas/ha. Para reducir el tamafio deI aparato vegetativo de los cafetos, la tercera parte de la plantacion fue podada cada afio a razon de una hilera cada tres. En la Finca Santa Fé, se realizo la comparacion entre una parcela a pleno sol y una parcela con *E. deglupta*. En esas parcelas, el café tenia 14 afios mientras que los árboles, que fueron plantados cuando el café estaba ya establecido, tenian 7 afios en el momento deI estudio. Las densidades de los árboles y de los cafetos eran de 120 y 5900 pies/ha, respectivamente. Las parcelas, en las cuales se recopilo la informacion sobre volumen de madera, biomasa de los árboles de sombra y de los cafetos y capa de mantillo, tenian un tamafio de 48 m * 48 m hasta 4 afios de edad y de 70m x 70m para el resta de edades. La metodologia consistio en establecer relaciones alométricas entre el diametro a la altura deI pecha (dap) Yla biomasa individual de 11-15 árboles por parcela (biomasa deI fuste, ramas y hojas por separado). Finalmente se aplicaron las relaciones alométricas calculadas al total de árboles inventariados en las parcelas, para obtener asi la biomasa por unidad de superficie. La estimacion de la biomasa acumulada en C. *arabica* se realizo mediante la seleccion aleatoria de 10-15 cafetos por parcela. Se pesaron por separado los tallos, ramas, hojas y frutos de cada cafeto seleccionado y se calculo el "cafeto medio" que permitio realizar la estimacion por unidad de superficie. El calculo de la materia seca acumulada en el mantillo se realizo tomando 8 muestras de 0.5 m^2 de mantillo por parcela. Cada muestra se constituyo de 2 cuadrados metalicos de 50 x 50 cm dispuestos sobre el suelo. La contaminacion deI mantillo por el suelo fue medida y el valor encontrado fue restado deI peso seco inicial deI mantillo, de tal manera que el resultado final representa solamente la materia orgánica. Para la evaluacion deI contenido de carbono de los diferentes componentes se utilizo una relacion C/MS de 0,48.

23. **Resultados**

Las relaciones alométricas halladas al utilizar la transformacion logaritmica tuvieron el mejor ajuste y el mejor nivel de significacion.

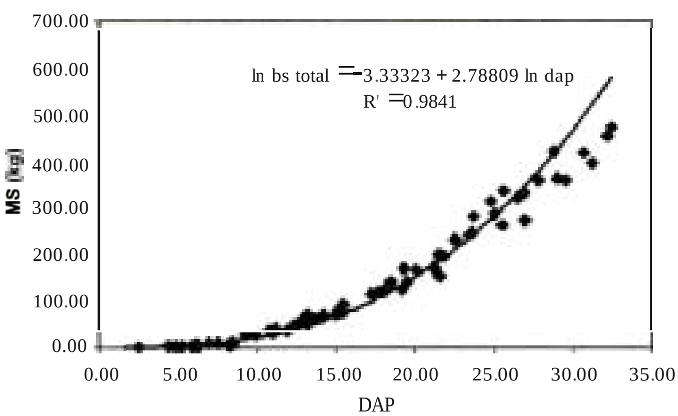


Figura 1. Biomasa aérea (en kg. de materia seca) de *E. deglupta* en funcion deI dap (cm)

La figura 1 ensefia la biomasa total aérea deI árbol según el dap medido a las edades de 2 à 7 afios.

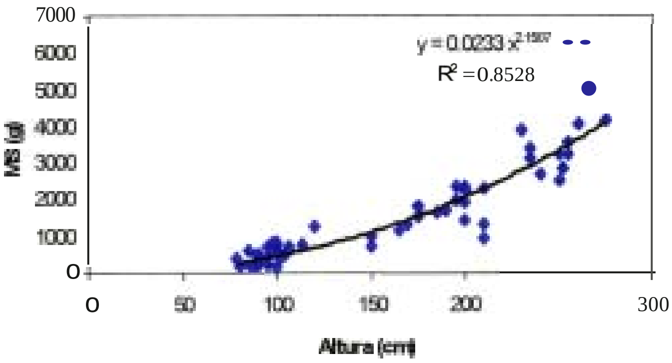


Figura 2. Biomasa aérea (g de materia seca) de C. *arabica* de 14 afios en funci6n de la altura (cm)

En el casa deI café, en las plantaciones homogéneas de 4 afios de edad, todavia sin podar, no fue posible encontrar una buena relaci6n entre un parametro fácil de medir y la biomasa deI cafeto. En cambio, en la plantaciones podadas cada afio, a raz6n de una hilera cada 3, existen tres clases de altura de los cafetos que corresponden aproximadamente a 3 clases de biomasa (Figura 2).

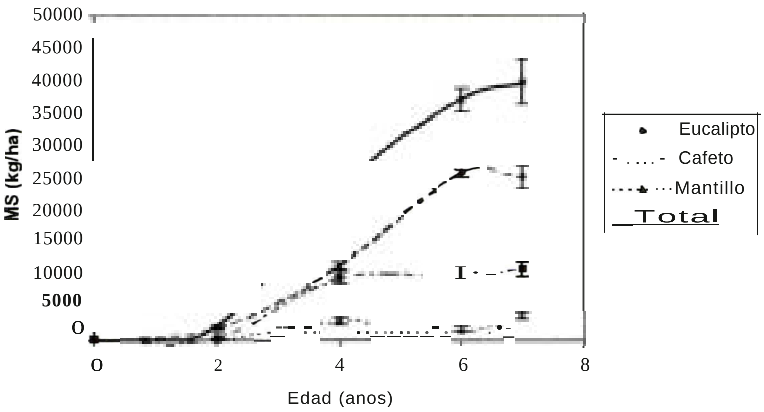


Figura 3. Biomasa y mantillo deI sistema C. *arabica* con *E. deglupta* en una cronosecuencia de rodales en la finca Verde Vigor

En Verde Vigor, a los 7 afios de edad, la biomasa de los árboles de sombra fue de 25,6 t MS/ha (12,5 t C/ha), la biomasa deI café de 10,8 t MS/ha (5,4 t C/ha) y el mantillo represent6 2,7 t MS/ha (1,3 t C/ha). Debido al control regular deI desarrollo vegetativo deI cafeto efectuado mediante la poda anual de la tercera parte de la plantaci6n, realizada a partir deI cuarto afio de edad, la biomasa de los cafetos no vari6 mucho a partir deI cuarto afio. De igual manera, la capa de mantillo tarnpoco aument6. Por eIlo, entre el cuarto y el séptimo afio, el incremento de la reserva de biomasa aérea deI sistema fue debida principalmente al crecimiento de los árboles de sombra. Se verific6, mediante mediciones hechas dos afios antes deI estudio, que los rodales de 6 y 7 afios tuvieron el mismo crecimiento durante los dos ultimos afios, por 10 que la ausencia de diferencia entre las dos edades (Figura 3) result6 de un retraso en el desarrollo inicial de la parcela de 7 afios. Esto lleva a pensar que, hasta la edad de 7 afios, *E. deglupta* no redujo su crecimiento en biomasa. Por 10 tanto es necesario seguir con las mediciones de biomasa en esta cronosecuencia para profundizar en la comprensi6n de la dinamica real deI sistema con sombra de *E. deglupta* y hacer la validaci6n de modelos de almacenamiento y fijaci6n de carbono de tipo C02 fix. Esos modelos serán utilizados para simular la evoluci6n de la reserva de carbono en este sistema. En Santa Fé, la comparaci6n entre el sistema de café a pleno sol y el sistema con sombra de eucalipto con 120 árboles/ha mostr6 que el árbol, introducido en un sistema de café ya establecido 7 afios atras, no tuvo, 7 afios después, ningun efecto negativo sobre la biomasa de los cafetos (20,4 t MS/ha 6 10 t C/ha), al menos sobre los componentes vegetativos. La mayor acumulaci6n de biomasa existente en los cafetos de Santa Fé respecto a los de Verde Vigor se explic6 por la mayor densidad de plantaci6n, la mejor fertilidad deI sitio y la mayor edad de los cafetos, los cuales tuvieron troncos más gruesos en Santa Fé. Sin embargo, la biomasa de los árboles fue similar en ambas fincas. En comparaci6n con el sistema de café a pleno sol, el sistema con sombra de *E. deglupta* de 7 afios de edad, aumenta la reserva de carbono almacenado en los componentes aéreos de 14,9 t C/ha, es decir, +150%. Las contribuciones respectivas de los arboles y deI mantillo en este aumento fueron de 12.9 y 2 tC/ha.

Tesis a presentar en diciembre 2002 por:
Sergio DE MIGUEL MAGANA
Dynamique de la biomasse de différents systèmes agroforestiers caféiers dans la zone Sud du Costa Rica. ENGREF Montpellier, CIRAD, CATIE.

Sustainability of coffee agroforestry systems in Central America; coffee quality and environmental impacts

Contract ICA4-2000-10327

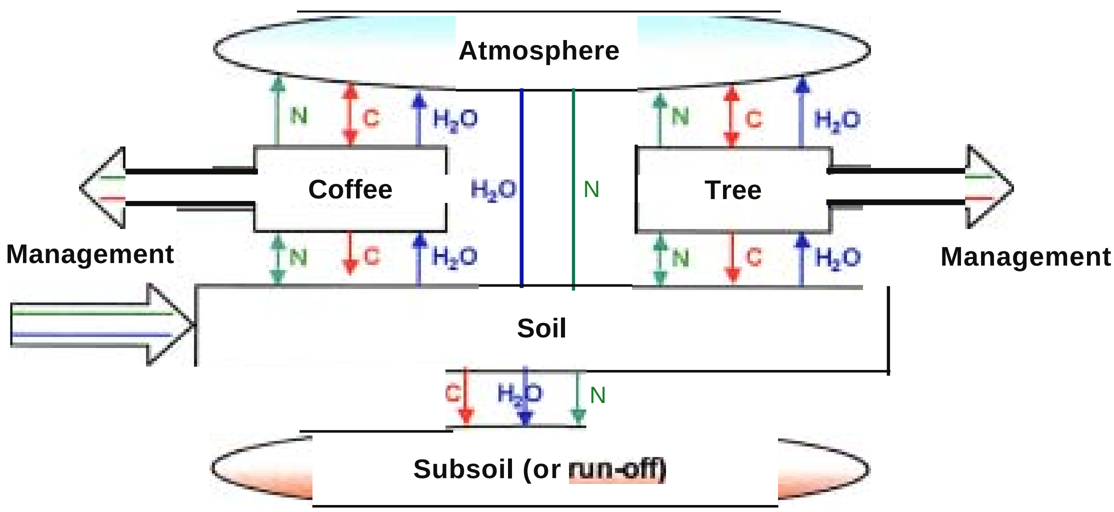
First Annual Report WORK PACKAGE 6
1 November 2001 - 31 October 2002
M. van Oijen, CEH, United Kingdom, leader of WP6

Objectives of Work package 6 (WP6): "Integrated Plot Modelling"

WP6 aims to develop a physiological model of the vegetative and reproductive growth of individual coffee plants in response to different levels of light, moisture and nitrogen as well as a plot-scale model of tree and coffee growth which includes competition for light, water and nutrients between shade trees and coffee plants, and management treatments such as spacing, thinning, pruning and fertilizing. WP6 draws on the information provided by the other biophysical work packages (WP2, WP3, WP4, WP5), and will, in later stages of the project, supply information on the biophysical aspects of coffee farming to WP7 and WP8.

Activities undertaken in WP6 from 1 November 2001 to 31 October 2002

(i)
Objectives, work plan and integration of activities between WP6 and the other work packages were discussed during the start up meeting of the project at CATIE, Turrialba, Costa Rica 26-30/11/2001. It was decided to build a model that can be used to analyse the effects of environmental conditions (weather and soil), competition with tree species, and management decisions (pruning, thinning, planting density) on coffee yield, use of nitrogen and water, and nitrogen leaching. The mode! is to simulate interception of light and fluxes of carbon, nitrogen and water between soil, plants and atmosphere (Fig. 1).



(ii)

As WP6 leader, CEH has distributed in December 2001 a work plan for this WP (included as Annex 6 to the Six month activity report 1 November 2001 – 30 April 2002, produced by CASCA-coordinator Dr. Philippe Vaast), which gives the time schedule of activities within WP6 and related work packages with respect to the tasks to be carried out in WP6 itself and in related work packages:

(1) Months 4-18: Acquirement of input data (weather, soils, management);
(2) Months 4-30: Transfer of information from WPs 2-5 to WP6;
(3) Months 4-36: Development of the integrated plot model itself;
(4) Months 6-48: Modelling of phenology and allocation;
(5) Months 6-48: Reporting;
(6) Months 38-42: Simplification of the integrated plot model and exchange of information with WPs 7 & 8.

(iii)

The leader of WP6 has developed an initial version of an integrated plot model for coffee growth with and without accompanying trees. The model has been implemented in the modelling software Matlab/Simulink, which allows both graphical representation of the model (useful in informing the other project participants about the modelling work) and efficient analysis. The model is already operational but its structure is intended to evolve further during the next two project years, in discussion with the researchers in the other biophysical work packages. The preliminary model comprises four biophysical components (coffee, trees, soil, atmosphere), as planned, and the coffee and soil components are subdivided further. The state variables and processes included in the different components of the current version of the integrated plot are:

1. Coffee
    - 1.1 Plant biomass variables (integration of organ growth rates, tracking the time courses of the dry weights of leaves, stems, roots, reserve carbohydrates and fruits)
    - 1.2 Phenology (flowering triggered by alleviation of water stress, i.e. spring rains resaturating the soil, followed by a fixed period until fruit maturation and harvesting)
    - 1.3 Light interception, source-sink dynamics and growth (effects of shading by trees on light interception, effects of water stress and reserve carbohydrate content on the amount of biomass formed per unit of light intercepted, and allocation of growth to the different organ systems proportional to the sink strengths of the different organs with fruit sink strength dependent on the phenological stage, and root sink strength dependent on the level of water stress)
    - 1.4 Leaf area growth (effects of water stress and reserve carbohydrate content on specific leaf area and thereby on the correlation between increase in leaf weight and increase in leaf area)
    - 1.5 Senescence (death rate of leaves as a function of temperature, shading and water stress)
    - 1.6 Root depth growth (linear root depth growth for young coffee plants until a soil or plant dependent maximum rooting depth is reached)
    - 1.7 Management (pruning, thinning and harvesting)

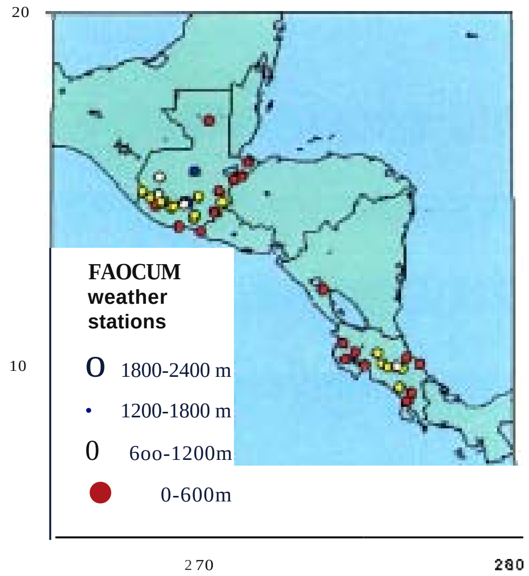
2. Trees (light interception with consequent shading of coffee plants, and uptake of nitrogen and water - all of which only in a preliminary form as time-invariant effects with values of zero representing the absence of trees, i.e. a coffee monoculture)
3. Soil
    3.1 Evaporation and transpiration (components of water loss from soil and plants as a function of soil water content, characterised by soil-specific parameters of the soil water retention curve, and the potential rates of evaporation and transpiration, calculated in the component 4, representing the atmosphere)
    3.2 Drainage, runoff and irrigation (remaining processes of the soil water balance)
    3.3 Nitrogen uptake by coffee and trees (nominally included, not yet activated)
    3.4 Nitrogen leaching (nominally included, not yet activated)
4. Atmosphere (calculation of day length as a function of latitude, setting atmospheric CO_2 concentration, reading weather data [radiation, temperature, precipitation, humidity and wind speed] from input files, and calculation of potential rates of evaporation and transpiration by means of a version of the Penman formula that accounts for the effect of leaf area index on partitioning of latent and sensible heat fluxes between soil and vegetation).

The simulation of physiological processes of the trees and the fluxes of nitrogen into and out of trees and coffee plants will be worked out in more detail after discussion with the various biophysical experts working in work packages 2, 3, 4 and 5.

Preliminary quantification of all parameters involved in simulating the processes listed above has been carried out. However, the model will need to be re-parameterised using biophysical data gathered by fellow participants; this is planned for the second and third project year.

(iv)

The integrated plot model developed in WP6 (see (iii)) requires site-specific weather data to run. The leader of WP6 has assembled relevant weather data files from the FAOCLIM database for model preliminary development, but the data are long-term averages and will have to be replaced by year-specific time series of daily data. The FAOCLIM data now used represent 15 stations in Costa Rica (3-2000 m. altitude), 1 station in Nicaragua (53 m. altitude) and 27 stations in Guatemala (1-2399 m. altitude) (Fig. 2). These stations do not coyer all major coffee growing regions well, nor do they provide any measure of day-to-day or year-to-year variability ofweather for any of the sites. It is concluded that better weather data need to be sought in the project.



(v)
The leader of WP6 has produced an outline of a review article "On the integration of physiological and architectural modelling of woody plant species" which is discussed with other project participants involved in biophysical research at the second CASCA workshop (see (vi» . The document will be expanded into a comprehensive overview of possible methods for combining the different approaches to modelling coffee plants and trees that are employed in the project. This will especially benefit the efficient incorporation of the submodels to be deve10ped in WPs 2, 3 and 4 into the integrated plot modelofWP6.

(vi)
WP6 activities are discussed at the second CASCA workshop at Managua, 24-30 October 2002.

Rapport WP7

Philippe Bonnal, CIRAD, leader ofWP7

Sten Guezennec & Alexandre Nougadère (étudiants du CNEARC)

Conformément à la programmation, les activités réalisées en 2002 dans le cadre du WP7 se sont concentrées, en lien avec le WP1, sur la collecte d'information sur les ménages agricoles. Les enquêtes ont porté essentiellement sur l'analyse des systèmes agraires et de production d'une petite localité représentative de la zone de production d'altitude du Costa Rica. Les informations collectées fournissent des points de repères importants pour la construction des modèles socio-économiques dont le début est prévu en 2003.

1. Les études sur les systèmes agraires et de production du Costa Rica.

Cette étude, conduite dans le "Valle central" et plus exactement dans les districts de Naranjo, Palmares et les 3 districts au nord de San Ramon a permis d'identifier les principaux critères de différenciation entre les systèmes de production qu'il s'agira de prendre en compte dans le modèle socio-économique. L'étude a mis en évidence plusieurs niveaux de différenciation.

i. Les zones de production.

Elles se différencient selon
- l'altitude et l'orientation du versants, ce qui , corrélativement, conditionne la température et la pluviométrie.
- l'histoire du peuplement : ancienneté, types de producteurs (niveaux de capitalisation), systèmes techniques mis en œuvre.
- la connexion au marché (disponibilité et qualité des routes).

ii. Les systèmes de production

Trois systèmes fondamentalement différents co- existent:
- l'exploitation familiale de petite taille (en général de moins de 5 ha) où l'ensemble du travail est assuré par la famille avec éventuellement un apport de main d'œuvre complémentaire salariée sous forme de travail temporaire,
- L'exploitation familiale patronale de taille moyenne (jusqu'à 35 ha) où le travail est assuré simultanément par des actifs familiaux et des salariés permanents,
- L'entreprise en général de grande taille (pouvant atteindre plusieurs centaines d'hectares) où le propriétaire délègue la gestion à un gérant et où la totalité de la main d'œuvre est salariée permanente (pour le fonctionnement incompressible de l'entreprise) et temporaire (pour les travaux saisonniers, notamment la taille et la récolte).

De façon évidente ces trois formes productives se retrouvent, selon des proportions variables, dans les trois pays pris en compte par cette recherche (Costa-Rica, Nicaragua et Guatemala).

iii. Les systèmes d'activités

Les systèmes d'activités sont, dans la zone étudiée relativement peu diversifiés: seuls deux trois systèmes sont repérables:

- Les systèmes centrés sur les activités agricoles,
- Les systèmes d'agriculture - élevage (notamment bovin-lait),
- Les systèmes de double-activités : salariat et agriculture.

iv. Les systèmes de culture

Contrairement aux systèmes d'activités, les systèmes de cultures sont très variables, les plus fréquents portent sur les associations suivantes :

- Café, tomate ou poivron (culture de rente)
- Café - banane (fonctions d'ombrage, alimentaire et rente)
- Café - dracaena (culture de rente)
- Café - canne à sucre (culture de rente)

v. L'association et le peuplement végétal au sein de la parcelle caféière

Dans la zone étudiée, dominent plusieurs systèmes:

- Le café sans ombrage,
- Café-banane,
- Café-eucalyptus,
- Café- dracaena
- Café - eurythryne

vi. Les itinéraires techniques sur café

Les itinéraires techniques se différencient selon le nombre de désherbages, le type (pied, parcelle) et la fréquence de la taille ainsi que par la présence et la nature de l'ombrage (plein soleil, sous légumineuse, sous bananier, sous eucalyptus).

2. Les enseignements tirés pour construire les modèles socio-économiques

L'importante diversité des exploitations agricoles obligera à ne retenir que quelques situations remarquables compte tenu des objectifs de l'étude. Ces situations porteront sur une combinaison entre les zones de production et les systèmes de production.

Pour chaque situation retenue, le modèle testera différentes activités, formations végétales au sein de la parcelle caféières et différents itinéraires techniques attachés aux activités, cherchant à identifier celles dont l'impact le plus fort pour le ménage agricole soit au regard d'agrégats significatifs (modèle Olympe sans optimisation) soit par le biais de l'optimisation d'une fonction d'objectifs multiples (MOLP).

Par ailleurs, la variabilité des pratiques culturales et des activités productives en réponse à la variabilité économiques et climatiques rend indispensable la prise en compte de différents états de la nature (années remarquables pour lesquels sont connus ou calculés les rendements des différentes activités agricoles et fourragères et les prix des intrants et des produits agricoles). Les rendements sont évalués par le modèle biophysique.

3. Les activités prévues en 2004

- Réalisation d'un stage d'analyse des exploitations agricoles au Guatemala.
- Réalisation d'un premier modèle sans optimisation (utilisation de Olympe) avec les données du Costa Rica (Valle central) et Guatemala.
- Construction d'un premier jeu de modèles d'optimisation sous contraintes utilisant les données du Costa Rica.

La réalisation de l'analyse contingente prévue dans le WP7 est actuellement en discussion, compte tenu du manque de disponibilité du chercheur qui s'était engagé à réaliser cette activité (affectation en poste en Afrique du Sud). La décision finale sera prise en 2003 de s'engager ou non dans cette activité.

De même, la définition des ateliers régionaux a été discutée au cours du séminaire annuel. Ces ateliers pourraient être substitués par des séances de restitutions, plus faciles à organiser.

ANNEX

Informe afio 1 (noviembre 2001- octubre 2002),

P.Bonnal (Cirad, departamento Tera, lider WP 7) y Estudiantes deI Cnearc

Durante el primera año, las actividades han sido de tres tipos: levantamiento y analisis de informaci6n al nivel de finca por medio de la organizaci6n de una pasantia de estudiantes, participaci6n a una coardinaci6n con los responsables de los m6dulos 1 (Eduardo Somarriba) y 8 (Gerry Lawson) entre otras personas, selecci6n definitiva de los modelos socio-econ6micos a realizar en el marco deI WP7 y participaci6n en las reuniones anuales deI proyecto CASCA.

La organizaci6n de la pasantia

Dos estudiantes deI CNEARC (Centra Nacional de Estudios Agron6mico para las Regiones Calientes) de Francia han sido seleccionados para realizar un estudio de fincas en marco deI proyecto CASCA. El primera estudiante, Alexandre Nougadère es de nacionalidad francesa, el secundo, Sten Guezennec, de nacionalidad luxemburguesa. Los dos se encuentran en el ultimo año de graduaci6n de ingenieria agricola, 10 cual es también en el primera año de Master of Science. Después deI praceso de selecci6n, durante el cual 6 estudiantes candidatos fueron entrevistados, los dos estudiantes escogidos viajaron en Costa Rica, donde permanecieron de abril 2001 a finales de agosto 2001 .

Selecci6n de la zona de estudio

Durante la visita de coordinaci6n entre los lideres de los WP 1,7 Y 8, fue decidido de concentrar los dos estudiantes en la zona deI valle central occidente de Costa Rica. Dicha zona es una de las regiones mas importantes deI pais desde el punto de vista de la praducci6n cafetalera y deI numero de fincas cafetaleras. El trabaj6 se limit6 en una pequena regi6n conformada par los distritos de Naranjo, Palmares y los 3 distritos al norte de San Ram6n, donde se concentra la mayor parte de la producci6n de la Provincia.

Realizacîon de la pasantia

La coordinaci6n deI trajo de los estudiantes fue realizada por Philippe Bonnal y Eduardo Somarriba (lider deI WP 1) basados respectivamente en Montpellier (Francia) y Turrialba (Costa Rica). Localmente, los estudiantes beneficiaron de un apoyo tanto logistico coma cientifico por los ingenieros deI Icafe (Orlando Lora Alfaro, José Eduardo Arias y Carlos Fonseca) y dellider deI proyecto (Philippe Waast) basado en San José.

Durante la pasantia, los estudiantes realizaron sucesivamente un analisis hist6rico de la implantaci6n de la cafecultura en la zona de estudio, una zonificaci6n, unas 110 encuestas de caracterizaci6n rápida de las fincas (estructura de la finca y de la praducci6n), unas 25 encuestas profundizadas al nivel de fincas (funcionamiento de la finca, caracterizaci6n de cafetal, estructura de los costos y de las recetas), una tipologia de los sistemas de producci6n, un analisis econ6mico de las fincas y una simulaci6n tentativa al nivel de las fincas.

Una memoria única para los dos estudiantes fue escrita (100 paginas mas anexos) y defendida el 22 de octubre en el Cnearc. Una version definitiva, corregida después de las observaciones realizadas durante la defensa, deberia ser disponible para el final des afio asi coma una sintesis en espafiol de 10 paginas mas mapas anexados.

Resultados

En primero lugar, este estudio confirma la grande diversidad de las fincas y de los sistemas agroforestales de la zona donde presencian fincas tan diferentes coma grandes empresas contratando una importante mana de obra asalariada y pequefios hatos familiares de pocas hectareas. Una grande diferencia se observa igualmente al nivel de los sistemas de actividades donde el cultivo deI café esta yuxtapuesto con un gran numero de actividades agropecuaria y/a no agricola.

Una zonificacion cualitativa de la zona fue realizado mediante entrevistas a personas claves, evidenciandose cuatro zonas con base a diversos criterios tales coma: forma historica deI poblamiento, conexion con el mercado, altitud, temperatura, lluvia y tipo de suelo. Dos zonas se encuentran en la zona baja : la cuenca de Palmares y la zona intermediara, y dos otras en la zona mas alta : las laderas de altitud y la Zona Norte de San Ramon. Las diferencias sefialadas anteriormente dan lugar a una diferenciacion de los sistemas de produccion desde el punto de vista de la estructura economica de las fincas y de las producciones agropecuarias incluyendo el café. Asi, los pequefios cafetales con sombra de leguminosas predominan en las zonas occidentales (cuenca de Palmares y zona norte de San ramon) mientras las grandes plantaciones sin sombra predominan en la zona de las laderas de altura y las grandes plantaciones de café con eucalipto se encuentran esencialmente en la zona intermediaria.

Las fincas pueden ser agrupadas en tres grandes tipos: familiar, patronal y empresarial. El tipo familiar se caracteriza por un uso exclusivo de la mana de obra familiar con excepcion de la cosecha cuando se suele contratar mana de obra temporaria. Las fincas de tipo patronal, a la diferencia de las precedentes, contratan regularmente una mana de obra asalariada, siendo ella permanente o temporaria, 10 que le permite extender el área cultivado de 3,5 ha en promedio (para las fincas de tipo familiar) a unas 30 hectareas. En fin, las fincas empresariales se caracterizan por la ausencia de la familia. La gerencia esta asegurada por un capataz y la totalidad de la mana de obra es contratada siendo 10 que toma la relacion entre familia y área cultiva invalida.

Dentro de cada tipo de fmcas existe una diversidad de sistemas de produccion, siendo los mas común (i) para le tipo familiar : café puro, café con cafia india, café con tomate o chile dulce, café con banano intercalado, (ii) para el tipo patronal café puro, café con cafia de azucar, café biologico y café con ganaderia lechera, (iv) para el tipo empresarial: café puro, café con eucalipto.

El analisis economico permite observar la variabilidad deI costa de produccion y deI valor agregado entre los varios tipos de cafetales e itinerarios técnicos. Cabe anotar el buen rendimiento economico tanto por hectarea (Valor agregado par ha) coma por unidad de trabajo (Valor agregado por dia de trabajo) deI sistema tradicional basado en la practica de la sombra con banano. El sistema de pleno sol también tiene un resultado economico interesante pero implica la necesidad de conseguir un excelente rendimiento fisico (en cima de 60 quintales[1] por hectarea). Si se consideran los sistemas de producci6n como un todo, es el sistema café con tomate y/o chile dulce que consigue los mejores resultados (siendo el valor agregado por trabajador en tomo de 20.000 $) seguido par el café con ganaderia lechera 0 con leguminosas (Inga spp. 0 Erythrina spp.).

Este estudio permiti6 la elaboraci6n de referencias precisas sobre los sistemas de producci6n y los itinerarios técnico. Sin embargo, un estudio complementar se encuentra necesario sobre el analisis de la poblaci6n vegetal de los cafetales ya que la encuesta botanica no ha sido realizada.

Encuentro entre los participantes de los WP 1, 7 Y 8

Entre los dias 21 y 28 de abril fue organizado un encuentro entre los miembros de Casca integrantes de los m6dulos 1, 7 Y 8 asi como una gira de campo en Nicaragua y Costa Rica. Este encuentro permiti6 realizar la selecci6n de las zonas a ser estudiadas por los estudiantes nicaraguenses (4 personas) y europeos (2 personas), la definici6n precisa de la programaci6n de las actividades de encuestas al nivel de fincas para los afios 2002 y 2003, la rectificaci6n deI cuestionario de encuesta y precisar la metodologia para el estudio de los sistemas forestales de las zonas correspondientes.

Seleccion de los modelos socio-economicos a realizar en el marco dei WP 7

Los dos tipos de modelos socio-econ6micos escogidos al inicio deI proyecto discutidos y revisados tomando en cuenta la evoluci6n de la disponibilidad de los investigadores deI Cirad. Los dos modelos finalmente previstos son : un modelo al nivel de fincas, de modelaci6n sin optimizaci6n y simulaci6n y un modelo de programaci6n matematica con optimizaci6n.

[1] de 46 kg

CASCA

First ADDual Report WORK PACKAGE 8

Regional Upscaling and Policy

First AnDual Report, December 2002

8.1 Introduction

Work-package 8: *Regional Upscaling and Policy*
Phase: First Year
Start date: 1/12/2001
Completion date: 31/12/2005
Current status: Ongoing
WP leader: GJ Lawson (CEH, Edinburgh)

Person months per partner and tota :

	CIRAD	CEH	CATIE	PROME-CAFE	UNA	Total
Technical Annex	1	2.8	10	12	8	33.8
Month 1-6		0				0.0
Month 7-12		0.5				0.0
Total First year		0.5				O.S

8.2 Objectives

Objectives ofthis Workpackage deal with upscaling results from the Biophysical plot model and from the socioeconomic model to gain an understanding of the validity of conclusions in a wider geographical area, and assessing the market opportunities for coffee-agroforestry systems in world and European markets: SpecificaIly:

1. To determine the requirements to achieve 'sustainable'; 'fair-trade' or 'eco-friendly' labels on the European markets as well as the long-term potential of marketing this coffee in European countries
2. To extrapolate farm-scale socio-economic survey data and model predictions from WP7 to a regional scale using population and agricultural census information
3. To extrapolate biophysical predictions ofyields and environmental impact from the plot scale biophysical model (WP6) to larger areas and regions using databases of soil and climate information.
4. To examine the regional implications for coffee production and farm livelihoods of changing climate, economic incentives and widespread uptake of 'eco-friendly' cultivation systems.

8.3 Methodology and study materials

During this first year input has mainly consisted of attendance at two project workshops and participation in a socio-economic field visit with stafffrom Workpackages land 7 to coordinate methodologies for characterising coffee farms, and bio-climatic zones. The intention was to design a robust sampling methodology which would be well-adapted to upscaling at a later date when soils, climate and coffee census information becomes available.

The Tasks identified for WP 8 are as follows:

1. Interviews with European traders to identify the requirements to achieve 'sustainable', 'fair-trade' or 'eco-friendly' labels on the European markets, and to forecast the growth ofthis market niche and the premium that European consumers are willing to pay
2. Use of socio-economic surveys and farm type to extrapolate impact predictions of coffee management from individual farms to predict impacts on the farming community in wider administrative regions
3. Use of information on climate and soil type to extrapolate biophysical predictions for individual plots to predict average yield and economics in wider regions
4. Examine the overall economic-environmental services of coffee agroforestry for different stakeholders.

8.4 Progress during the first year

8.4.1 Task 1 (Identification of Market for shade coffee).

An initial survey of the market for different coffee labels was conducted, with identification of five categories of labelling schemes a) organic coffee; c) conservation or shade-grown coffee; d) fair trade coffee; d) non-label initiatives consumer labels: (Annex 1). These schemes have diverse requirements for tree density, canopy height, species choice, management methods, type ofprocessing and even type ofpackaging used (Annex 1). There is no doubt that there are economic markets to be gained for small-scale growers who are using organic or controlled shade methods, but the market and management constraints are very diverse, and also changing constantly. During the next year it is intended to produce a database of the requirements for each label and the implications for typical growers.

8.4.2 Task 2 (Extrapolation of Socio economic farm surveys to rRgional Economie Scale)

The availability of information has been checked with Coffee Growers Organisations (ICAFE and PROMECAFE) on: a) producers per Province & Canton; b) production per producer, and long-term trends; c) degree of technification; d) location and altitude of each producer; average distances to Bbnificadoras; e) information available from the National Census, f) population in each Province and Canton; g) average size of farms?; h) average crop production patterns; f) average family sizes; g) econonomic details on other employment.

Sorne of this information has been collected for the single area sampled within WP7, and is reported there. Visits have been made to the National Census office in San Jose, and a trial questionnaire is being designed for regional CICAFE offices).

8.4.3 Task 3 (Extrapolation of Biophysical Predictions at Plot scale to Regional Geographie Scale)

Information is awaited from CICAFE on the Coffee Atlas of Costa Rica. Information has been provided by UNA and UNICAFE on the Coffee Atlas of Nicaragua and currently been analysed.

8.4.4 Task 4 (Overail Environmental Services of Coffee Agroforestry for Different Stakeholders)

A literature review has been undertaken on the environmental impacts of coffee plantations (not included with this report but being circulated amongst partners). Data on existing projects and studies is being collated in the following area: a) Carbon Trading, the - Clean Development Mechanism and Joint Implementation including the valuation of C-Stocks and GHG emissions; b) Carbon Inventory techniques and the contribution of multistrate agroforestry to national emissions targets;c) contribution of coffee-agroforestry to sustainable timber production; d) services to catchment water supply, flood control and quality; e) ecotourism potential; f) biodiversity services in country and regionally. Sorne preliminary costings are available (Table 8.1).

Type of Benefit	Amount (US$/ha)
Water supply	8-16
Loss of productivity of hydroelectric dam	15-25
Agriculturalland preservation	2-4
Flood control	4-8
Carbon sequestration	400-600
Ecotourism	6-12
Firewood production	10-20
Tirnber production	10-20
Biodiversity	4-10

Table 8.1: Tentative values ofenvironmental and other services ofplantations (PROCAFE 1999)

8.5 Deliverables

There were no deliverables planned in the first year

8.6 Milestones and expected results

There were no milestones planned in the first year, but substantial progress is expected towards the following milestones in the next 12 months:

1. Completion of interviews with European traders and estimates of premium priees that European consumers are willing to pay for eco-friendly produced coffee (Month 42)
2. Extrapolation of outputs from the socio-economic farm model (WP7) to predict impacts of different management scenarios *on farmers* at the level of administrative region (Month 36)
3. Extrapolation ofplot-scale biophysical model results to predict regional yield and environmental impact on a GIS grid, for at least one country (Month 36)
4. Integration of socio-economic-ecological impacts of coffee management systems in the context ofbroader environmental impacts on stakeholders (Month 40)

9 Annex 1: Market Opportunities and Constraints for Shade-Grown Coffee.

9.1 Coffee Consumption Patterns

The US, Gerrnany and Japan are major importers of coffee, with the European Union importing a total ofalmost 40 Million 60kg sacks (Figure 8.1).

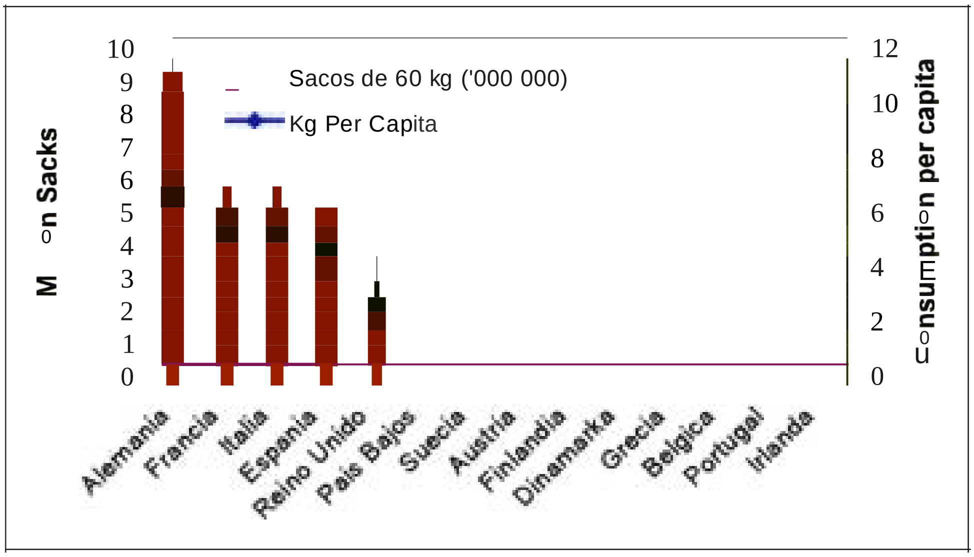


Figure 8.1: *Consumption ofcafé in the EU en 2001* (33.2 *million sacks of60kg); US=18.6 Million sacks, Japan* 8.3 *M sacks*

9.2 Coffee LabeUing Initiatives

There are four types of coffee labelling scheme: a) Organic Coffee; c) Conservation or shade-grown coffee; d) Fair Trade Coffee; d) Non-Label Initiatives.

9.2.1 Organic Coffee

Organic farming was originally 'maintenance of soil health and fertility' but has extended IFOAM defines as

- *Organic agriculture includes ail systems that promote the environmentaily, sociaily and economicaily sound production offood andfibres. These systems take local soilfertility as the key to successful production. By respecting the natural capacity ofplants, animals and the landscape, it aims to optimise quality in ail aspects ofagriculture and the environment*

- *Organic agriculture dramaticaily reduces external inputs by refrainingfrom the use of chemico-synthetic fertilizers, pesticides and pharmaceuticals. Instead it ailows the powerful laws ofnature to increase both agricultural yields and disease resistance.*

The International Organic Accrediting Service has 600 members in 100 countries - but only 2 are Tegistered in coffee producing countries (2000): BoliCert of Bolivia and Instituto Biodinamica of Brazil. Non-member organic certifiers include Eco-Logica in Costa Rica and Cenipae in Nicaragua.

The IFOAM organic coffee standards place numerous constraints on growers: a) Qualifying farms must devise a farm plan, including separation of non-organic production and the safe-guarding of uncultivated land to serve as natural habitat; b) genetically modified seeds of plant stock are prohibited; c) soil fertility must be maintained through natural means such as ground cover, 1eguminous 'companion plants' composting and natural supplements ifnecessary; d) pests and weeds must be controlled through preventative maintenance and mechanical control (e.g. insect traps, manual weeding) or by naturally derived substances; e) synthetic herbicides, fungicides and insecticides are prohibited; f) sorne naturally occurring chemicals (e.g. copper salts) are allowed but restricted; g) measures must be taken to conserve water and soil at all stages of production; h) roasters must ensure product separation and other procedures to prevent contamination by non-organic material; I) chemical extraction (e.g. chemical decaffeinating) is not allowed; j) roaster must have policies to minimise packaging

There are three other organic standards: a) the European Union Regulation *2092/91* is similar to IFOAM but has no specifie criteria for conservation of soil water and biodiversity, nor for social criteria. It is more detailed on requirements for processors and testing programmes. 'Third country' certification is possible for the whole EU once a local certificate has been evaluated and accepted by one of the the Member States; b) Codex Alimentarius is a set offood standards developed by FAO and the WHO, and draft guidelines for organic production and labelling have been published; c) the USDA-National Organic Programme standards willlimit use of 'organic' to roasters who are not only buying-organically-grown coffee but who have also certified their roasting plants and warehouses

9.2.2 Conservation or 'Shade-Grown' Coffee

Sustainable Coffee Congress (1996) was watershed in highlighting conservation attention in US - e.g. 150 species of migratory birds that breed in N America live in coffee plantations during winter (60 million bird enthusiasts in the US are a big market).

There are 6 initiatives: a) Smithsonian 'bird friendly' criteria; b) Eco-OK programme; c) Country Programmes; d) Industry Sourcing Programmes; e) Consideration of Coffee as a Non-Timber Forest Product; f) Inclusion of Shade in Organic Certification Requirements

Smithsonian Bird Friendly Coffee involves rustic or traditional polyculture[1], in which coffee is planted under existing diverse forest cover is most desirable for birds. In the case of planted shade trees, native species with year-round foliage should be used. Species oOnga are recommended. A minimum of 10 species of shade trees is required, distributed evenly and creating different strata. There should be at least 40% shade cover from the canopy after pruning. The shade should be at least 12 meters high, and Stream buffers and living fences are also desirable.

The **ECO-OK Programme Developed** was by Rainforest Alliance and Fundacion Interamericana de Investigacion Tropical (FUT – Guatemala) & now managed by Conservation Agriculture Network (Costa Rica, Brazil, Ecuador, Guatemala & El Salvador). To qualify producers must: a) maintain or establish a canopy of mixed native trees, b) keep at least 10 species of native trees in the productive part oftheir farm with at least one representative of each species per manzana; c) ensure a density of shade trees of at least 70/ha; ensure that at least 40% of the productive part of the farm is shaded, with at least 70% of the trees evergreen; d) conserve epiphytes on shade trees, and ensure that at least 20% of the shade trees are emergent (15+ meters); e) pruning should be is restricted to the dry season, and must leave at least 50% of fruits and flowers.

The **Fair Trade Programme** seeks to ensure that the vast majority of worlds coffee farmers get a fair priee for their harvests'. It began in late 1950s as 'alternative trade organisation', in small outlets in Europe. The Max Havelaar Fair Trade Seal was launched 1988, and also offered to large coffee companies who could trade a proportion of output on 'fair trade' terms. Other EU national initiatives followed - e.g. 'TransFair' in Germany.

Fairtrade Labelling Organisations International (launched 1998) consists of 19 labelling organisations sharing common criteria for each product (coffee, tea, bananas, cocoa, sugar, honey & organge juice). Costs are paid by roasters in developed countries - not by the producers. Criteria include a) purchase directly from small farmers organized into democratically-run cooperatives (no criteria for coffee estates, as opposed to tea & bananas); b) guarantee a floor priee when world market priees are low; d) offering farmers credit to help cover harvest costs; d) developing long-term trading relationships between importers and farmer co-operatives; e) including cooperatives in the 'International Fair Trade

1 The Smithsonian Institute defmes a cultivation intensity series of 'rustic shade' > 'planted shade' > 'diverse commercial polyculture' > 'less diverse commercial polyculture' > 'specialised shade' . The last two are not certifiable.

Coffee Register'; f) providing credit is available at commercial rates once contract to purchase is signed – as advance on delivery;

There are no specified fann practices for Fairtrade Coffee, but the floor price is higher for organic coffee. Producer groups themselves have specified environmental protocols, but these are not yet adopted. So far there are 300 coffee producer co-operatives (550,000 small fanners), 100 importers & 19 Fair Trade Labels, 50 million Euros/year wholesale.

The market share is 5% in Rolland and Switzerland. The floor price is $l.26/lb ($1.41/lb organic) = $127/qt ($142.99/qt), and $0.15/lb more than market price if above this. Roaster and importers paya $O.lO/lb licence fee, with no cost to producer. Sorne coffees 'double certified' at no extra cost to producer.

Coffee eertified as a non-timber forest produet. is under consideration by Forest Certification groups like SmartWood and the Forest Stewardship Council, and sustainable riteria have been developed for other NTPFs such as nuts, oils, gum, woodland plants. The FSC is also collaborating in 'joint inspections' with organic certifiers.

Industry Sourcing Guidelines and Policies also exist. US examples include Thanksgiving Coffee (CA), Sustainable Rarvest (CA), Elan Organic Coffee (CA), Counter Culture Coffee (NC), & Organic Products Trading (WA). The Speciality Coffee Association of America (SCAA) has guidelines which specify that: a) species composition of shade trees should be characterised by multiple species, with a prediominance ofregionally native species (not exotics); b) shade tree canopy should be structurally diverse, with a minimum oftwo layers above the coffee – the topmost layer should have a minimum canopy height of 10-12 meters; c) shade tree canopy foliage should provide a significant amount of shade (40% coverage or more after pruning)

The industry itself calls for further research to define a) the pruning of shade trees, b) the minimum number of shade tree species; c) the importance of epiphytes, vines and parasitic plants. Starbucks 'Coffee Mission Statement' iwas ssued after pressure from Guatemala Labour Rights Project , and smaller roasters have significantly stronger mission statements regarding employment and environmental conditions on estates - e.g. 'just cup' criteria.

There are also country specifie programmes independent of the international licencing bodies. Examples are: a) El Salvador (PROCAFE) is developing national programme to develop criteria for shade-grown coffee in conjunction with Salva Natura (with GEF funding). Organic fanning is promoted but is not required. b) Chiapas, where the Union de Ejidos de La Selva and the MacArthur Foundation are assisting and marketing organic coffee in buffer zone for Montes Azules Biosphere Reserve; c) Colombia and Ethiopia are also developing national organic certification and marketing programmes which include standards for shaded) Costa Rice, through COOCAFE has 9 cooperatives who are marketing 'Café Forestal; and 'EcoLogica'.

CASCA Initial Workshop - Report
CATIE, Turrialba, Costa Rica 26-30/1112001

General information

The workshop was held from November 26-30/2001 in CATIE, Turrialba, Costa Rica, according to the program detailed in Annex 1. A total of 25 persons attended the meeting, representing the 7 associated institutions as listed in Annex 2. A field visit was made to one of the potential research sites in the South of Costa Rica.

This report is intended to sUffi up the most important information exchanged and decisions taken regarding planning of the project activities during this initiation workshop of our project.

Presentations of institutions by participants and of Work packages by their leaders will be inc1uded in the CASCA Website to be developed in the coming months.

AlI workshop participants received a "green folder" containing the most relevant information regarding financial and administrative aspects of the CASCA project. This folder should serve as the reference for CASCA activities and financial control and be refereed to throughout the project duration.

On administrative and financial aspects:

- the most important points are fund management and periodic report writing. Two decisions (1 & 2) surnmarize the discussion on these issues. An important aspect is that funds should be spent according to financial planning (especially for scientific equipment) without de1ays that will impede our ability to ask the E.U for future disbursements.
- A second important point worth mentioning is the fact that the chronic coffee crisis has had financia1 impacts on the coffee institutions, especially ANACAFE, and is like1y to affect their capacity and dedication to the CASCA project.

Information regarding coffee agroforestry systems **and trials already in place**

In Costa Rica:

Coffee is associated with service trees (e.g., *Erythrina poeppigiana)* as the predominant agroforestry system in this country. The forestry incentive program (1986-1992) favoured the introduction of timber trees in coffee plantations of Costa Rica.

During the last 10 years, CrCAFE has initiated a number of trials consisting of one large plot per treatment with different commercial tree species (service and timber) and fruit trees.

Year	Location	Species			
1995	VC	Poro	Eucalipto	Laurel	Cedro
1996	Perez	Poro	Eucalipto	*T ivorensis*	*T amazonia*
1997	LS	Poro		Eucalipto	-
1997	Cicafé	Poro	Inga	Musa	Full sun
1999	Turrialba	Poro	Roble	Laurel	Cedro

Inga: *Inga edulis*
Poro : *Erythrina poeppigiana*
Eucalipto : *Eucalyptus* spp.
Laurel : *Cordia alliodora*
Cedro : *Cedrela odorata*
Terminalia : *Terminalia amazonia* or *Terminalia ivorensis*
Musacae : mostly plantain
Roble: *Tabebuia rosea*

In general, a decrease in coffee production of 20% is observed with eucalyptus in comparison with other tree species and especially Poro; the coffee yield reduction is in the order of30% with musacae.

There are also a nurnber of system trials established since 1996 comparing the semi-conventional system *(50* % ofrecommended inputs) with MIP and organic systems.

Apart from the CrCAFE trials, CATIE also has in Costa Rica two large coffee agroforestry trials (in Turrialba on CATIE land and in Perez Zeledon on the industrial plantation of Verde Vigor) visited during the workshop field trips.

Further discussion is needed with CrCAFE to select the trials that should complement the two CATIE trials for gathering data on biophysical aspects.

In Nicaragua:

In the Pacifie lowlands, coffee is associated with mixed shade where *Gliricidia sepium* predominates. At higher altitudes in the northern part of the countries, systems associating coffee and *Inga* species and/or musacae (mostly plantain) predominate.
Farmers also considered citrus species as a very important component oftheir farrning system. Many farmers are interested in introducing timber tree species, especially cedro, in their coffee fields
Apart from the two system trials established by the MIP/AFlNorad project of CATIE in the Southern Pacifie lowlands, little information is available on existing trials and plots of potential interest for CASCA. Hence, there is an urgent need to come up with a census of existing plots to determine the ones (if any) that can be used to gather biophysical data on coffee-tree associations for the CASCA project.

In Guatemala:

According to ANACAFE, tree and other plant species associated with coffee *(Coffea arabica)* in Guatemala are in order of importance:

- *Inga* sp. : 75%
- *Grevillea robusta:* 10%
- *Gliricidia sepium* : 4%
- *Erythrina* sp. : 4%
- Musa: 6%
- Citrus
- other fruit trees (avocado,...)
and robusta coffee: 5%

There is an urgent need to come up with a census of existing plots of interest for CASCA.

Regional MIP/AF/Norad project of CATIE

With the objective of evaluating the potential of several tree species in diverse ecological conditions, this project has established in 2001 a network of fann trials with a participatory approach. The associations of coffee and species are :

Country	Tirnber	Service	Fruit
Costa Rica	*Cedrela odorata* *Cordia alliodora*	*Erythrina poeppigiana*	Citrus
Nicaragua	*Cedrela odorata*	*Inga* sp.	Avocado Orange
Guatemala	*Cedrela odorata* *Cordia alliodora*	*Inga* sp.	Musacae

in the following ecological conditions :

		Altitude (m.a.s.l.)	Dry months	Number of plots
Guatemala	Santa Rosa	800-1200	6	5
	Cobán	< 800	2	12
Nicaragua	Jinotega	1000-1200	3	5
	Matagalpa	700-800	4	5
Costa Rica	Perez Zeledon	<800	4	4
	Turrialba	<800	2	3

Although these trials are fairly young «2 years), they are very interesting for CASCA due to the various conditions and species present.

Selection of agroforestry systems to be taken into consideration by CASCA due to their relevance :

Following discussion, it appears that the following coffee-tree combinations should be studied in trials and/or plots to gather biophysical data on their interactions :

Coffee : - *CofJea arabica* var. Caturra

Timber species

Eucalyptus deglupta
Cordia alliodora
Cedrela odorata
Terminalia amazonia & *T. ivorensis*

Service trees :

Inga sp
Erythrina poeppigiana
Gliricidia sepium

Not only combinations of coffee and a timber species or a service tree should be considered but also the association of coffee with a timber and service species.

Although banana and fruit trees are important components of the farming systems, it has been decided that these associations will solely be studied from an economic point of view without undertaking detailed investigation at the biophysicallevel.

Biophysical modeling of the coffee-tree association

In order to start modeling the growth of coffee and an associated shade tree, their interactions and resource sharing in terms of solar radiation, water and nitrogen have to be evaluated in order to predict their production and impacts in different ecological conditions. The modelers of CASCA have presented a list of key parameters that need to be collected :

Standing biomass;
Foliar indices;
Roots (biomass, rooting profile);
Resource fluxes: light interception, water consumption, nitrogen fluxes, level of inputs and variation according to ecological conditions;
Tree age and seasonal phenological changes;
Leaf fall and pruning regime;
Coffee yield components;
Daily weather data : temperature (max-min), rainfall, global radiation, relative humidity, wind;
Soil properties: especially porosity, soil water content (vol %) at field capacity and at permanent wilting point;
Soil fertility: especially N & organic material.

Economical modeling at the farm level and regional up-scaling

Strategies of producers and socio-economic surveys
Socio-economic surveys are needed to undertake a modeling effort at the farm and regional scales. These surveys should be based on existing typologies in the different countries.

Identification of main agroforestry systems

Selection of "representative" farms

Socio-economical characterization

One of the main difficulties for regional up-scaling is that the current zones of coffee production are more administrative ones than eco-zones.

Main "zones" of production	Typologies to undertake
Costa Rica : 7	Costa Rica: 4
Guatemala : 8	Guatemala : 8
Nicaragua : 5	Nicaragua : 4

Coffee atlas in Nicaragua and Guatemala as well as a GIS in Costa Rica are being developed and should be useful tools.

Following discussion, it appears an important effort has to be undertaken during the first year of the CASCA project to gather socio-economic data.

To start this surveying process, a meeting of leaders of WP 1-7 & 8 should take place in April 2002 in either Nicaragua or Guatemala following a selection of graduate students (CATIE of Costa Rica, UNA of Guatemala, CNEARC of France & agricultural university of Guatemala) and defmition of priority zones.

Discussion on the deliverables of CASCA

During the workshop, participants also focused on what should be the main products of the CASCA projects:

1. tools to monitor cash flow
2. information to reduce risk (at ecological, agronomie & climatic levels)
3. technical recommendations / species /management
4. tools to determine compatibility between production of a system and coffee quality
5. information regarding market opportunities :
   - coffee / quality

- timber products
- values of environmental services (carbon, water quality, soil conservation, landscape, biodiversity)

6. recommendations (legal and technical) on commercial timber exploitation
7. tools to monitor economic viability
8. user-friendly models

The following socio-economic aspects have also been discussed :

7.2 Contingent Valuation Method
This method will be focused primarily on the following aspects:
Carbon
Nitrogen
Biodiversity

7.3 Multi-objective model
It should be based on an existing model developed by INRA and ClRAD.

8.1 Prospective information on European markets for coffee
CATIE has links with NGOs and universities working on these aspects, especially in Bolland. CIRAD will also interview traders and roasters.
Several participants insisted on the fact that studies should also be undertaken on the timber market (not envisaged in the deliverables of the CASCA project).
Contact should be made with Manuel Gomez (CATIE) currently studying financial aspects related with timber production in coffee agroforestry systems.

8.4 Economic and environmental services for different stakeholders :
The challenge is that this is addressed to a wide range of stakeholders (from farmers to governmental & international institutions). Main results of the CASCA project will be presented in workshops.

Decisions

The most important decisions taken during this workshop are the following :

1. Each institutionalleader is responsible to manage the funding according to the budget items per year. They are to send a financial report to the coordinator every 6 months. The first one is due for mid-April 2002.

2. Activityreport (6-18-30-42 months).
According to the E.U guidelines, a 1-2 page report has to been written by each participating institution (cflist of administrative leaders for institutions in Annex 3) and WP leader (cflist ofWP leaders in Annex 4) outlining work under way and problems encountered; this to allow the coordinator to prepare a project report combining all these reports and with an additional overview of progress.
The first one is due for mid-April 2002.

3. Databases on selected coffee agrosystems
   In order to help Marcel (leader of WP6) start the modeling process, the foIlowing persons are in charge of coIlecting existing information regarding the selected agroforestry systems, particularly biomass data, and should produce an informaI report for the beginning of April 2002 (to be part of the first activity report):

   - *Inga* sp. : Bayron Medina
   - *Erythrina poeppigiana* : Carlos Fonseca
   - *Gliricidia sepium* : Victor Aguilar
   - *Eucalyptus deglupta* 0 *E. grandis* : Jean-Michel Harmand
   - *Cordia alliodora* : Markku Kanninen
   - *Cedrela odorata* : Jeremy Haggar

4. Census of existing coffee agroforestry trials or plots.
   In order to select trials or plots of interest to gather biophysical data and parameters, there is a need to undertake rapidly a census of existing coffee-shade trials or plots in Guatemala and Nicaragua.

5. Programs ofresearch activities by Workpackage.
   Before the end of February 2002, each WP leader needs to propose a tentative planning ofresearch activities for the duration of the project (as shown for WP6 by Marcel in Annex 6).

6. Meteorological databases.
   In each country, we need to collect meteorological data for aIl the main coffee eco-zones. For the sites with experiments in progress, meteorological data should be gathered by Philippe/Jean-Michel (San Isidro) Carlos & Philippe (Barva) and Jeremy and Victor (Nicaragua) to be sent to Philippe V. who will forward the data needed for WP6 to Marcel. For the other coffee regions, the administrative leaders *(i.e.* Carlos for Costa Rica, Francisco for Guatemala and Glenda for Nicaragua) need to get in contact with the National Meteorological Institutes oftheir countries so that daily weather data can be gathered and sent to Marcel during the second half of 2002 (see Annex 6).

7. Meeting of socio-economists in Guatemala in April 2002 to define survey content and select regions.

8. The next consortium meeting of CASCA will take place in Nicaragua from October 28 to November 1 2002. For this meeting, it is expected that each WP leader and administrative leader will provide a copy oftheir annual report (for guidelines, see Annex 3 and annexes ofproject contract).

Annex 1

Detailed Program of CASCA Workshop at CATIE from 26/11/01 to 30/11/01

Monday 26/11/01:

8 :00- 10:00 am

Presentation of individual participants at the workshop and the partner institutions (Gerry for CEH, Markku/John for CATIE, Bayron for ANACAFE, Carlos for CrCAFE, Glenda/Victor for UNA and Philippe Y./Jean-MicheI/Jean/Philippe B./ Bernard for CIRAD)

10 :30 - 12 :00 am

General presentation of the project (Philippe V. & Jean-Michel)

1 :00 – 5 :30 pm (including coffee break at 3 :00)

Presentations (1/2 h each) of the workpackages by WP leaders

Eduardo : WP1 (CA coffee agroforestry knowledge)
Jean: WP2 (light and water partitioning at plot scale)
Philippe V: WP3 (coffee ecophysiology and quality)
Jean-Michel : WP4 (nitrogen cycling)
Markku : WP5 (carbon sequestration)
Marcel: WP6 (integrated plot modeling)
Philippe B : WP7 (economic modeling at farm scale)
Gerry :WP8 (regional up scaling and policies)

Tuesday ***27/11/01:***

8 :00 - 12 :00 am (including coffee break at 10 :00)

areas of interest and foreseen participation of individualslinstitutions; selection of tree species and agroforestry system trials for biophysical WPs and zones in 3 countries for socio-economic diagnostic at farm level

1 :00 - 5 :30 pm (including coffee break at 3 :00)

Group discussion on workpackages

Wednesday 28/11/01:

8 :00- 10:00 am

Group discussion on WPs

10 :30 - 12 :00 am :

Wrap-up meeting

1 :00 - 5 :30 pm:

Visit of CATIE agroforestry trials

Thursday ***29/11/01:***

7 :00 am : Departure to Perez Zeledon

aU day visit ofcoffee agroforestry trials in Santa Fé and Verde Vigor and late-afternoon visit of CoopeAgri beneficio
Night in Perez Zeledon

Friday 30/11/01 :

8 :00 - 12 :00 am

Visit of CrCAFE trials, office, laboratory and agroforestry systems
Back to San José at 5:00 pm and Turrialba at 5:30 pm

Annex 2

List of participants at the CASCA Workshop 26-30 November 2001

ANACAFE:	email
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DATA SHEET FOR ANNUAL REPORT

Contract number : ICA4-2001-10071

First Year
(November 1st 2001 to October 31st 2002)
Data sheet
for annual report of CASCA

	Totals
J. Dissemination activities (cumulative)	
Number of communications in conferences (published)	1
Number of communications in other media (internet, video, **poster)**	1
Number of publications in refereed joumals (published)	O
Number of articleslbooks (published)	O
Number of other publications	O
2. Training	
Number of PhDs	2
Number ofMScs	12
Number of visiting scientists	10
Number of exchanges of scientists (stays longer than 3 months)	2
3. Achieved results	
Number of patent applications	O
Number of patents granted	O
Number of companies created	O
Number of new prototypes/products developed	O
Number of new tests/methods developed	O
Number of new norms/standards developed	O
Number of new softwares/codes developed	1
Number of production processes	O
4. Industrial aspects	
Industrial contacts	no
Financial contribution by industry	no
Industrial partners : - Large	no
-SME [1]	no

S. *Comments*

Other achievements

A brochure is in preparation for the **Salon International d'Agriculture** to be held in Paris, France, from February 22od to March 3rd 2003 with the objective to present the CASCA project to the general public and the European coffee sector.

, Less than 500 employees